EXAMINING AND CHARACTERIZING CHANGES IN FIRST YEAR HIGH SCHOOL CHEMISTRY CURRICULA

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Many students currently entering college are able to solve mathematical problems but often do not understand the chemistry concepts underlying their calculations. High school chemistry teachers from Texas and the United States (US) were surveyed as to what topics they teach in their chemistry classes. A subset of Texas teachers was also interviewed about their instruction.

The survey indicated that less-experienced Texas teachers are omitting a number of topics from their chemistry instruction, as compared to more experienced teachers. No differences were seen for those topics among US teachers. Chemistry textbooks from 1930 to the current 2002 Texas state adoptions were analyzed for inclusion of these topics. The only textbooks that were missing topics were from the 1930s. All others contained the topics. In general, textbooks have been increasing numbers of questions and problems for each topic, with the number of quantitative problems increasing at a greater rate than qualitative problems.

Analysis of interview transcripts revealed that the main reason for omission of topics by less-experienced Texas chemistry teachers is that these topics are not assessed on the Texas Assessment of Knowledge and Skills science exam. Omitted topics were both qualitative and quantitative; the common factor is that they are not tested. School administrators reportedly reinforce this practice.

Archival data regarding textbook usage by general chemistry students showed that students’ course grades are not correlated to the amount of time they spend using
their textbook. With topics included in textbooks, and no relationship between textbook usage and student grades, observed changes in chemistry courses must be due to changes in classroom instruction.

With new course standards adopted by Texas for chemistry and the development of end-of-course exams, these changes should produce graduates who understand chemistry concepts as well as they solve mathematical chemistry problems. Repeating this study in 5 years may show that increasing the amount of chemistry tested will produce students entering college with a better conceptual background in chemistry.
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CHAPTER I

INTRODUCTION

High school students can calculate the energy of photons of light, but cannot identify the metal in a compound by the color it produces in a flame. Chemistry professors notice that freshman chemistry students can solve mathematical problems but have little or no comprehension of the chemistry underlying the calculations. Chemistry, as a single science, started out as observation—observe what happens when substances react. However, with the advent of today’s emphasis on computational outcomes, is chemistry now turning into calculation practice?

Statement of the Problem

Education and its quality continue to be topics of intense interest in the United States (US). Standardized tests continue to be forced upon students and teachers in the name of accountability. There is also growing concern that many students who graduate from high school are not academically prepared for success in college or for a career. The number of entering college freshmen who need remediation in order to succeed in college continues to climb. Based upon international testing, the performance of US students continues to fall behind that of their peers in other countries.

In the areas of science, technology, engineering, and mathematics (STEM), the situation is critical. Student success in these areas has been linked to increasing innovation, improving the economy, and contributing to national security (National Governors Association, 2008). US industries and companies that rely on highly trained
STEM graduates are concerned that they must increasingly rely upon students from other countries in order to find qualified employees.

While education in the US has been greatly affected by world events in the past, concern currently centers on students’ preparedness for life after high school. Programs that adequately prepared students for college success in the past are now seen as falling short of that goal. What has changed?

Part of this problem arises from the national goal of preparing every student for college. While reality dictates that not every student can or should attend college, many more are finding themselves continuing schooling after their high school graduation. This has undoubtedly contributed toward the increase in students needing remedial courses as they start college. However, many more students who would have been adequately prepared for postsecondary success are now struggling to keep up with their courses.

In college, general chemistry courses are required by an increasing number of majors. Almost every science major requires at least one year of general chemistry; increasingly, this requirement is also appearing in requirements for a variety of engineering degrees as well along with degree plans for the health professions, food sciences, and some non-science majors’ programs. Since there are very few remedial chemistry courses, students’ preparation for success in chemistry courses comes entirely from their high school coursework. It is essential, then, that the content of high school chemistry instruction be examined for changes that may be responsible for any decrease in student success in general chemistry courses.
Over the past several decades, a number of chemistry instructors believe that teaching chemistry has become much more focused on mathematical problem solving rather than qualitative description of materials and their chemical reactions. This trend has been reported in college general chemistry textbooks and is more recently evident in Texas’ newly adopted instructional standards for high school chemistry. Likewise, as technological advances have made electronic calculators more powerful and more affordable, their use has been incorporated into high school chemistry textbooks.

However, these changes are not necessarily translated into changes in instruction. Changes to textbook content take years to occur, and in Texas they are also subject to the State Board of Education’s instructional materials adoption cycle. Some teachers lag in their inclusion of new technology in classroom instruction, likely due to lack of either experience with or funding for equipment. Students usually have more time to devote to learning about and practicing with new electronic devices, and can more readily apply new technology to their classroom and laboratory activities. These devices also greatly simplify routine computational problems in chemistry, allowing teachers to assign more practice problems without increasing students’ total time required for homework. This can lead both teachers and students to believe that chemistry is more numerical and mathematical than it is observational and descriptive.

Data Sources for the Study

In order to make an in-depth analysis of content in high school chemistry, both textbooks and teachers' opinions of the current state of education need to be examined. A selection of high school chemistry textbooks covering a broad range of years was chosen (Table 1). Several of the textbooks predate the successful launch of the Sputnik
satellite by the USSR; this event prompted the US government to fund the greatest changes in US science education in the 20th century (Merrill & Ridgway, 1969). The textbooks that precipitated from this federal mandate have also been included, as are two others from the 1960s and 1970s. Two series of textbooks officially adopted by the Texas State Board of Education in 1987, 1993, and 2002 were also chosen. For one of these series, there were two editions between the 1993 and 2002 adoptions that were included to complete the progression. In total, 14 textbooks were evaluated.

Table 1

*Textbooks Analyzed (*Texas-adopted textbooks*)

<table>
<thead>
<tr>
<th>Era</th>
<th>Title of Text</th>
<th>Authors</th>
<th>Date</th>
<th>Publisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Sputnik</td>
<td>Chemistry for Today</td>
<td>McPherson, Henderson, &amp; Fowler</td>
<td>1930</td>
<td>Ginn and Company</td>
</tr>
<tr>
<td>Pre-Sputnik</td>
<td>A First Book in Chemistry (3rd ed.)</td>
<td>Bradbury</td>
<td>1934</td>
<td>Appleton-Century Company</td>
</tr>
<tr>
<td>Immediately Post-Sputnik</td>
<td>Chemistry: An Experimental Science</td>
<td>CHEM Study (Pimentel, ed.)</td>
<td>1963</td>
<td>W. H. Freeman and Company</td>
</tr>
<tr>
<td>Immediately Post-Sputnik</td>
<td>Chemical Systems</td>
<td>Chemical Bond Approach (CBA) Project (Strong, ed.)</td>
<td>1964</td>
<td>McGraw-Hill Book Company</td>
</tr>
<tr>
<td>1960s-1970s</td>
<td>Chemistry: A First Course in Modern Chemistry</td>
<td>Garrett, Richardson, &amp; Montague</td>
<td>1966</td>
<td>Ginn and Company</td>
</tr>
<tr>
<td>Holt Series</td>
<td>Modern Chemistry*</td>
<td>Metcalfe, Williams, &amp; Castka</td>
<td>1986</td>
<td>Holt, Rinehart, &amp; Wilson</td>
</tr>
<tr>
<td>Holt Series</td>
<td>Modern Chemistry*</td>
<td>Tzimopoulos, Metcalfe, Williams, &amp; Castka</td>
<td>1993</td>
<td>Holt, Rinehart, &amp; Wilson</td>
</tr>
<tr>
<td>Holt Series</td>
<td>Modern Chemistry*</td>
<td>Davis, Metcalfe, Williams, &amp; Castka</td>
<td>2002</td>
<td>Holt, Rinehart, &amp; Winston</td>
</tr>
<tr>
<td>Addison-Wesley/Prentice-Hall Series</td>
<td>Chemistry (2nd ed.)*</td>
<td>Wilbraham, Staley, &amp; Matta</td>
<td>1987</td>
<td>Addison-Wesley/Prentice-Hall</td>
</tr>
<tr>
<td>Addison-Wesley/Prentice-Hall Series</td>
<td>Chemistry (3rd ed.)*</td>
<td>Wilbraham, Staley, Simpson, &amp; Matta</td>
<td>1993</td>
<td>Addison-Wesley/Prentice-Hall</td>
</tr>
<tr>
<td>Addison-Wesley/Prentice-Hall Series</td>
<td>Chemistry (4th ed.)</td>
<td>Wilbraham, Staley, &amp; Matta</td>
<td>1997</td>
<td>Addison-Wesley/Prentice-Hall</td>
</tr>
<tr>
<td>Addison-Wesley/Prentice-Hall Series</td>
<td>Chemistry (5th ed.)</td>
<td>Wilbraham, Staley, &amp; Waterman</td>
<td>2000</td>
<td>Addison-Wesley/Prentice-Hall</td>
</tr>
<tr>
<td>Addison-Wesley/Prentice-Hall Series</td>
<td>Chemistry (6th ed.)*</td>
<td>Wilbraham, Staley, Matta, &amp; Waterman</td>
<td>2002</td>
<td>Addison-Wesley/Prentice-Hall</td>
</tr>
</tbody>
</table>
To add perspective to the textbook analysis, knowledge of student textbook utilization was also examined. This portion of the study was carried out using archival data collected by Dr. Mason at The University of Texas at San Antonio in spring 2000. Students in general chemistry classes reported their textbook usage activities on a weekly basis; students \((n = 65)\) were included in the analysis if they completed at least two-thirds of the surveys during the semester.

Two groups of chemistry teachers \((n_1 = 81 \text{ and } n_2 = 44)\) were surveyed, consisting of those who elect to spend their own time (and frequently their own money) to attend conferences where they can learn how to improve and enhance their chemistry teaching. By attending to their own classroom performance, these teachers are more likely to identify changes in their instruction that may or may not match the trend seen in textbooks. Therefore, they are an excellent population to survey for this study. ChemEd 2009 (ChemEd 09), an international biennial conference for high school chemistry teachers, was held at Radford University, Radford, Virginia, in August 2009. At this conference, teachers from all across the US were surveyed. Texas chemistry teachers were later surveyed in November 2009 at the Conference for the Advancement of Science Teachers (CAST). This 2009 annual meeting of the Science Teachers Association of Texas (STAT) was held in Galveston, Texas. Additionally, a small group of Texas chemistry teachers at the same meeting were recruited for interviews to add depth to the survey results.
The Purpose of the Study

The purpose of this study is to examine classroom instruction and materials for evidence of shifts in emphasis from chemistry as descriptions and observations to chemistry as theory-based calculations.

Research Questions

Through examination of first-year high school chemistry instruction and materials, what evidence is there, if any, of shifts from chemistry as descriptions to chemistry as calculations from 1985 to 2010?

(1) As reported by high school chemistry teachers, what shifts, if any, have occurred and how have they affected classroom instruction?

(2) For any documented shift noted in part 1, what reasons do high school chemistry teachers give to support concurrent shifts in instruction?

(3) What identified shifts from chemistry as a descriptive science to chemistry as a quantitative science and/or the reverse are documented in chemistry textbooks from 1985-2010?

Definition of Terms

ACT®: the ACT test assesses high school students' general educational development and their ability to complete college-level work. The multiple-choice tests cover four skill areas: English, mathematics, reading, and science. The Writing Test, which is optional, measures skill in planning and writing a short essay. (ACT was originally an abbreviation of American College Test; today, it is referred to only by the initials ACT.)
First-year high school chemistry: A science course normally undertaken by public school students in their tenth- (sophomore) or eleventh-grade (junior) school years; the first formal chemistry course in Texas public schools. (In Texas, this course is now required for most students to graduate from high school, but at the time of data collection, it was considered to be an optional course only taken by the typically college-bound student.)

High-stakes test: A standardized test (or set of tests) on which students must earn passing scores in order to move from one level of school to another, or to graduate from high school. (Passing test scores are required in addition to successful completion of all course requirements in order to graduate from high school.)

Qualitative or descriptive chemistry: How elements and compounds react with each other, and what one observes during these reactions. Also refers to patterns of chemical behavior as well as how to use these observations to differentiate between substances.

Quantitative chemistry: The calculations and numerical relationships utilized in the study of chemistry.

SBOE: State Board of Education—This is an elected 15 member board which, along with the Commissioner of Education, oversees the public education system of Texas in accordance with the Texas Education Code. This group (at the time of this study) makes the final decisions regarding curriculum (the TEKS) and all Texas-adopted textbooks and instructional materials.
STAAR: State of Texas Assessments of Academic Readiness—The STAAR name will be used for the 12 end-of-course assessments and the new grade 3-8 assessments. The new tests will be used beginning in the 2011-2012 school year (http://www.tea.state.tx.us/index4.aspx?id=7874). Students in the graduating Class of 2015, who are currently in seventh grade, will be the first students who must meet the end-of-course testing requirements, as well as successfully complete their classes, in order to earn a diploma.

TAKS: Texas Assessment of Knowledge and Skills—Texas’ program of standardized testing for its public school students. (TAKS is a high-stakes testing program.)

TEKS: Texas Essential Knowledge and Skills—Texas’ curriculum standards for its public schools. Both classroom instruction and all teaching materials in Texas public schools must conform to these standards.

Significance of the Study

While there is an abundance of research establishing what content most chemistry instructors consider essential for coverage in a first-year high school chemistry course, there has been very little research into what content is actually taught in these courses. Indeed, a thorough search of the literature in this area reveals that only one similar study of high school chemistry teachers has been conducted (Deters, 2006). In this dissertation study, self-reported content coverage by high school chemistry teachers will compare instructional practices in Texas and the rest of the United States. Additionally, interviews conducted as part of this study will provide deeper understanding into the reasons teachers give for including or excluding chemistry topics in their instruction.
Almost all published textbook analyses have been conducted with contemporaneous texts, generally to provide a comparison to assist instructors in their selection of textbooks for classroom use. While the content of college general chemistry textbooks over the past century has been reported, there is only one published study (Abd-El-Khalik, Waters, & Le, 2008) that examines changes in high school chemistry textbook content over time. Similarly, there is little published research that addresses how students utilize their textbooks, or how that utilization relates to their academic achievement. This study will add a great deal of information to these sparsely examined topics.

Limitations of the Study

Several significant limitations apply to the teacher surveys and interviews. Samples of convenience were used for both administrations of the topic survey as well as for teacher interviews. While both samples included teachers from various community environments, such as urban, suburban, or rural, no effort was made to obtain equal representation from each subgroup. Similarly, the geographic distribution of the respondents was not controlled. Also, information self-reported by teachers was considered to be reliable but was not independently verified. However, roughly equal groups of teachers, by levels of experience, were obtained during each survey administration.

As a practical matter, selection of textbooks for analysis was limited for this study. A representative sample of high school chemistry texts spanning the years 1930 to 2002 was chosen, including a number of Texas-adopted books. Series of textbooks from two different publishers were also selected; while both include books adopted in
Texas, one series includes two consecutive editions that were not adopted in Texas. (The next textbook adoption cycle for chemistry in Texas was to be in 2012 (TEA, 2010b), post-dating this research. However, the 2012 Proclamation was postponed indefinitely in May 2010 (TEA, 2010a).)

Within the time frame of the textbooks chosen for evaluation for this study, data were collected in spring 2000 by Dr. Mason at The University of Texas at San Antonio for the purpose of an in-depth analysis of the ways that students actually use their textbooks. Students self-reported their hours of textbook usage per week and their rating of textbook usefulness from 1 (not useful) to 10 (very useful). Some students rounded all values off to whole numbers, while other reported fractions. Approximately one-third of the 94 students submitted fewer than 10 of the 15 weekly surveys and therefore was excluded from analysis.
CHAPTER II

REVIEW OF LITERATURE

Introduction

In order to determine if a shift of instructional emphasis has taken place for a particular subject, a content baseline must be established. This baseline includes curricular documents, textbooks, and the classroom practice of current classroom teachers in the subject area. Previous shifts in content and instruction must also be examined for similarities and differences with current changes being studied. Significant historical events that precipitated changes in instructional emphasis help provide context for prior curricular shifts.

Analysis of curricular materials is paramount in documenting an instructional trend. Content standards for textbooks and instruction must be investigated as they dictate changes in course content. Likewise, textbook content can drive classroom instruction, especially for inexperienced teachers, making analysis of textbook content essential to determining the presence and extent of shifts in instructional emphasis. Additionally, knowledge of student utilization of textbooks can provide valuable insight into the impact of textbooks on student achievement.

Classroom teachers are the ultimate arbiters of course content which is actually taught. They must be queried for topics covered during first-year high school chemistry courses. Teachers’ beliefs and opinions also have significant impact on their day-to-day instruction, so their insights into trends and changes in instructional emphasis are vital to fully characterizing the content of current classroom instruction.
Learning theories must guide examination of curriculum and instruction as they clarify the processes students use for assimilating and understanding course content. Learning theories also provide a framework for students’ thought processes as they learn how to answer questions and solve problems using course content. It is logical, then, to first examine relevant learning theory as it applies to learning high school chemistry. This will be followed by historical examination of high school chemistry course content and the processes outside of the classroom that help define it. Finally, background into teacher perceptions and self-reporting will illustrate other vital variables that shape content in classroom instruction.

Theoretical Prospectus

*Learning Theory: Problem Solving and Its Context*

In developing a context for learning chemistry, the work of Piaget and Bloom must be considered. Piaget’s theory of cognitive development consists of a progression of thought process skills as children grow older (Karplus, 2003). Since much of chemistry involves abstract concepts, it is generally expected that a student’s problem-solving capability in chemistry is a direct reflection of their level of cognition. As Karplus (2003, p. S54) observes, “a large fraction of students will use concrete reasoning patterns extensively.” However, if a student has a particularly strong interest in a topic or an experiment, then they may be able to function at a much more abstract level than might otherwise be expected (Hall, 2000).

Bloom’s taxonomy also applies to classroom teaching and assessment. Unfortunately, many instructors conduct the majority of their teaching at lower levels of Bloom’s taxonomy such as knowledge and comprehension (Eber & Parker, 2007). The
science of chemistry, though, frequently relies on skills at higher levels of cognition such as analysis and synthesis. At the analysis level, students examine a system’s parts to determine how they are related to each other and to a larger learning scaffold. Student assessment is simpler at lower levels of cognition, despite the fact that it likely is not measuring a student’s capabilities in chemistry so much as that student’s talent for recalling information in rote memory.

Provided that instruction is occurring at higher levels of cognition, two learning theories help explain how students learn to solve various problems in chemistry courses. Discovery learning, originally described by Jerome Bruner (Kearsley, 2009), holds that learning is an active process in which learners construct new ideas of concepts based upon their current and past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. In this example of constructivism, cognitive structure provides meaning and organization to experiences and allows the individual to “go beyond the information given.” Chemistry concepts such as descriptive chemistry are learned mainly through this theory’s process.

In Schoenfeld’s mathematical problem solving theory (Kearsley, 2009), understanding and teaching mathematics should be approached as a problem-solving domain. This theory maintains that four categories of knowledge/skills are needed to be successful in mathematics:

- **Resources** - proposition and procedural knowledge of mathematics
- **Heuristics** - strategies and techniques for problem solving such as working backwards or drawing figures
- **Control** - decisions about when and what resources and strategies to use
- **Beliefs** - a mathematical “world view” that determines how someone approaches a problem
Quantitative chemistry education occurs mainly through the processes of Schoenfeld's theory. Students use discovery learning to build the conceptual foundation that supports the resources, control, and beliefs students need in the mathematical problem solving process. Problem solving in chemistry may also clarify heuristics students initially learned in mathematics courses, facilitating transfer between mathematics and science. As a consequence, chemistry students need to develop both their qualitative conceptual framework for chemistry and their quantitative problem-solving skill. With both kinds of knowledge, students have the capability to solve many types of chemistry problems presented to them.

History of Chemistry Course Content

Often credited as the father of modern chemistry, Antoine Lavoisier published a number of works detailing the experimental techniques and equipment he used to observe a very large number of chemical reactions. Perhaps the most extensive of these was Elements of Chemistry (Lavoisier, 1965 (original French published 1789)). Translated to English in 1790 by Robert Kerr, this text describes Lavoisier’s findings with regard to boiling and evaporation, atmospheric gases, reactions involving “caloric” (heat), and a wide variety of reactions involving acids and bases. He also reported his experimental techniques in great detail and provided extensive drawings to help describe the numerous articles of glassware and other laboratory equipment that he developed and built for his experiments. In order to report his observations, he developed a detailed nomenclature for chemical elements and compounds, much of which is still in use today.
In many cases, Lavoisier made and reported careful measurements of substance masses and container volumes for comparison before and after reactions. He also used fairly accurate thermometers to permit the use of volume-temperature proportionalities in his observations of gas behavior. His accurate measurements and observations formed a foundation upon which many other chemists built knowledge in a full range of chemical reactions and processes.

As this compilation of descriptive chemical information was constructed and expanded, learning chemistry meant learning a great many chemical facts and reactions (Bodner & Pardue, 1989). For example, examination of one textbook designed for use in a first chemistry course (Young & Porter, 1958) shows that the first five chapters of the book cover basic principles of chemistry such as atomic theory, general chemical reaction calculations, and definition of numerous terms used in chemistry. The remaining 16 chapters of the text describe chemical reactions and processes. The stated goal of the text is “to guide general science students in the acquirement of a working knowledge of the basic facts and principles of chemistry” (p. v). The result is a textbook that covers many chemical reactions without much basis in theory. Despite the fact that, at the time of the book’s publication, electron configurations were accepted and taught as the model of electron arrangement in atoms, this book instead uses Bohr “orbit” models for this purpose.

For those studying chemistry at the college level, Pauling’s General Chemistry text was much more thorough (Pauling, 1988 (originally published 1970)). In the preface, the author states that he “attempted to simplify the teaching of general chemistry by the correlation of the facts of descriptive chemistry, the observed
properties of substances, to as great an extent as possible with theoretical principles” (p. v). He incorporated a great deal of the mathematical development of these principles in his discussions, but the end-of-chapter exercises required very little use of this information in order to answer the questions. Pauling was very conscientious about including recent scientific discoveries in each new edition of his textbook; the third edition referenced here contains a chapter on fundamental particles with information that was originally published only six years before this edition.

The successful launch of the Sputnik satellite by the Soviet Union in 1957 served as a wake-up call for education in the United States (US) (BSCS, 2006). With the prospect of losing the “space race” to the Soviets, the US government passed the National Defense Education Act in 1958. Title III of that act provided funds to strengthen science and mathematics education (Jolly, 2009). Programs to accomplish this began soon after passage of the legislation, with research scientists and high school teachers working together to create new curricula in three areas of science: biology, chemistry, and physics. In chemistry, these programs took shape as the Chemical Education Material Study (CHEM Study) and the Chemical Bond Approach (CBA) project (Merrill & Ridgway, 1969; National Museum of American History, 2009). Under the leadership of chemistry Nobel Laureate Glenn Seaborg, CHEM Study development was housed at the University of California, Berkeley. Laurence E. Strong, Earlham College, led the CBA efforts. Each project produced a textbook, a laboratory manual, and a variety of audiovisual and teacher ancillary materials. CHEM Study was a laboratory-based course and emphasized that chemistry is an experimental science, stressing the importance of careful and detailed observation (Seaborg & Campbell,
1963). Using the nature of chemical bonds as a connecting concept, CBA materials combined descriptive chemistry with the principles that explain it. This integrated approach to chemistry instruction continues in wide use today (Bodner & Pardue, 1989).

Both projects were designed for all students who take high school chemistry and aimed to teach students to think scientifically. They were extensively field-tested and revised based upon high school teachers’ recommendations. Interestingly, those who originally viewed the CHEM Study materials thought they were too advanced for high school students; after one year’s experience, it was found that the content was well within the learning capabilities of these students.

Development of Curriculum Standards

As with Sputnik, another perceived crisis in the quality of public education in the US resulted in further changes in chemistry course content. However, A Nation At Risk prompted action from governmental and educational agencies, as opposed to earlier reliance upon chemical researchers and teachers (United States National Commission on Excellence in Education, 1983). States developed their own standards for what material was required to be taught in each grade level or course from kindergarten through high school graduation. In Texas, these standards were called essential elements (EE) (TEA, 1987). For chemistry, as for other high school sciences, there were ten statements written broadly enough to be identical for each science. Sub-elements of each EE were general concepts for each science, but these were evidently not considered to be specific enough and were supplemented further with an extensive list of 13 suggested topics. Both the EE and the topics list leaned toward qualitative chemistry, specifying “sequence a qualitative analysis scheme” (TEA, 1987) but not
directly mentioning stoichiometry. Chemistry textbooks adopted in 1993 were required to be correlated to the EE; the chemistry books in the 1987 adoption were correlated to the EE retroactively.

In 1995, Texas passed new legislation that charged the State Board of Education (SBOE) to establish a required curriculum for grades K-12 (TEA, 1996). Now called the Texas Essential Knowledge and Skills (TEKS), writing teams were assembled in each main subject area to produce these lists. The science team was made up of teachers, administrators, business and industry representatives, scientists, college-level educators, and parents. Teacher feedback on the draft TEKS was sought statewide, and minor modifications were made prior to the adoption of the full curriculum by the SBOE in 1998 (TEA, 2009b). Following the final approval of the TEKS, chemistry textbooks up for the 2002 adoption were required to address all the TEKS in order to be considered (TEA, 2004). While being more specific than the EE, the original TEKS were still largely qualitative and did not include any required calculations be addressed.

Having been in use for ten years, the science TEKS were in need of revision and update. A panel of chemistry educators at the high school and college levels drew up more quantitatively robust TEKS, and comments were solicited from educators and the public. A number of science supervisors protested the inclusion of any mathematics in the new chemistry TEKS, fearing that any required calculations will cause students to fail the course (Holley, 2009). However, the SBOE ultimately adopted the originally recommended standards that included more than a dozen required new calculations for students to perform.
While individual states developed their own curriculum standards, the National Academy of Sciences set out to produce a set of National Science Education Standards (NSES) that could be used as a basis for comparison or as a reference for the development of state-level standards (National Research Council, 1996). The purpose of this document was clear:

The National Science Education Standards present a vision of a scientifically literate populace. They outline what students need to know, understand, and be able to do to be scientifically literate at different grade levels. They describe an educational system in which all students demonstrate high levels of performance, in which teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are focused on learning science, and in which supportive educational programs and systems nurture achievement. The Standards point toward a future that is challenging but attainable—which is why they are written in the present tense (p. 2).

The NSES go far beyond state curriculum standards. They include standards for science teaching, professional development for science teachers, assessment, programs, and systems. All of the NSES are constructed upon the definition of science as an experimental and inquiry-based field of study. For high school chemistry, the content standards are written around four main ideas: structure of atoms, structure and properties of matter, chemical reactions, and interactions of energy and matter. The concepts and principles to be included in these areas are presented descriptively, with opportunities for quantitative problem solving suggested but not directly stated.

The NSES have been widely accepted by science teachers and scientists. The American Chemical Society has taken this a step further by publishing its own guidelines for chemistry as it appears in the NSES (Bretz, 2008). An area of emphasis is the utility of mathematics in various chemistry problem-solving situations. Skills in mathematics are used to make predictions for an experiment or to analyze data from an
experiment. As technology continues to advance, its utility in making sense out of chemical phenomena increases.

The most recent incursion of governmental mandates into chemistry education is the No Child Left Behind (NCLB) Act of 2002 (US Department of Education, 2009). Building on previously required state curriculum standards, the main impact of this reauthorization of the Elementary and Secondary Education Act is forcing states to implement assessment procedures to show that these standards are helping their schools improve student performance. In Texas, this resulted in a series of high-stakes tests known as the Texas Assessment of Knowledge and Skills, or TAKS (TEA, 2009a). More recently, the Texas Legislature voted to eliminate the science subject-area TAKS and create end-of-course (EOC) exams called STAAR (State of Texas Assessments of Academic Readiness) exams for many high school courses including chemistry. These new exams will be based on the recently revised TEKS in chemistry that have been aligned with algebra I and the 2008 adopted Texas College and Career Readiness Standards (TCCRS), and these are expected to increase classroom emphasis on newly specified quantitative problem-solving skills (EPIC, 2008).

College Readiness

One main goal of the NCLB Act is to ensure that all students have the requisite skills for success at the post-secondary level (US Department of Education, 2007). This has resulted in a new round of standards being produced to clarify what is expected of high school graduates when they enter college. The College and Career Readiness Standards (Common Core Standards Initiative, 2009) have been adopted by 48 US states; Alaska and Texas opted to generate their own versions of similar readiness
standards. The TCCRS were adopted by the Texas Higher Education Coordinating Board in 2008 (EPIC, 2008). Along with content standards, the TCCRS also lists a number of performance indicators as examples of how students may demonstrate mastery of the content. Prominent among the performance indicators for chemistry are a number of calculations that were not included in the first edition of the chemistry TEKS. It is apparent that the second edition of chemistry TEKS needed to include more quantitative problem solving, if students are to be equipped for success in college chemistry.

There are a number of courses that have been shown to facilitate student success in college. One of the earliest courses demonstrated to improve students' college readiness was the CHEM Study course (Merrill & Ridgway, 1969). Outlines for similar courses have been published by the ACT. Their recommended content for high school chemistry emphasizes various mathematics skills (ACT, 2005).

Various skills are often cited as needed for student success at the college level. Logical thinking skills and study skills are of paramount importance (Conley, 2007; Mitchell, 1989, 1991; Sharps, Hess, Price-Sharps, & Teh, 2008). Depth of topic coverage is also an indicator; students who covered one major topic in depth, for a month or longer in high school, earned higher grades in college science, even when adjusted for other variables such as socioeconomic status (Schwartz, Sadler, Sonnert, & Tai, 2009). Students whose high school laboratory experiences were more inquiry-based were more likely to succeed in college chemistry (Tai, Sadler, & Loehr, 2005). Mathematics skills are also significant predictors of success in college chemistry (Mittag & Mason, 1999; Tai, Sadler, & Loehr, 2005; Tai, Ward, & Sadler, 2006).
Textbook Analysis

Textbooks are integral tools in high school chemistry instruction. Critical analysis of chemistry textbooks can help define both the content and presentation of instruction. Numerous references exist for various methods of quantitative textbook analysis (Doran & Sheard, 1974; Kulm, Roseman, & Treistman, 1999; Penney, 2000; Siler, 1987; Soyibo, 1996; The University of Texas, 2006; Wang, 1998). Topics for analysis include readability, content, presentation of material, questioning styles, mathematical demands, and quality of illustrations. Several investigators have examined how the nature of science is presented in various textbooks, including how science takes place and what constitutes scientific thinking (Chiapetta, Fillman, & Sethna, 1991; Chiapetta, Sethna, & Fillman, 1991, 1993; Harrison, 2001). Attention has also been directed toward textbook depiction of the history of science (Leite, 2002).

Comparison of science and mathematics textbooks with national curriculum standards has found significant deficiencies in coverage (Haury, 2000). To quote Haury, "These are sobering findings given the extent to which teachers use textbooks to guide instruction and determine the content of the curriculum" (p. 2).

Most of the above textbook analyses are conducted with current or new textbooks available at the time of analysis. Analysis of a series of textbooks over time are far less common but have been found (Abd-El-Khalik, Waters, & Le, 2008; Bailar, 1993).

Student Utilization of Textbooks

The impact of textbook content upon a student’s success in chemistry is partially a function of how the student uses their textbook for a particular course. It has been
observed that textbooks that are clear, concise, and contain useful information actually give medical school lecturers the opportunity to concentrate instruction on more practical aspects of clinical medicine (Huth, 1969). It has also been reported that students use a textbook more often when it is available online, especially if the text is highly interactive (Baker, Thierstein, Fletcher, Kaur, & Emmons, 2009). Two different reading behaviors have been described among students in an introductory accounting course (Phillips & Phillips, 2007). Academically strong students were observed to access textbook content prior to lecture and to persevere when content becomes difficult for them. Weaker students read to reduce anxiety and tend to stop reading, if comprehension of content becomes difficult.

**Student Perceptions of Textbook Usage**

Students’ perceptions of what makes a good sixth grade social studies textbook have been described (Crismore, 1989). Generally, students wanted their textbooks to be interesting and to address values and feelings. They liked having clearly written prose with understandable graphics. Students looked for several features that are also found on the Friendly Text Inventory (Singer & Donlan, 1989), such as chapter summaries, glossaries, and questions. This is in contrast to how teachers viewed the same textbooks: as non-literary but informative prose.

The previous research by Singer and Donlan (1989) has limited application in this study. High school chemistry textbooks are not usually written as narrative prose, but to convey scientific knowledge to students. A fair amount of that knowledge focuses on processes, such as writing equations and calculating chemical quantities, as
opposed to telling stories. However, the previous research does confirm the characteristics that make a textbook friendly to students.

Teacher Perceptions

Having examined a number of influences on chemistry course content, examination of the perceptions of classroom teachers is appropriate. It is the actions and thoughts of the classroom teacher that determine, on a daily basis, what is ultimately taught during chemistry class. This, in turn, has direct bearing on student success both in the current course and in future courses beyond high school.

While there are multiple listings of state curriculum standards for high school chemistry, there is also much debate among high school and college instructors as to what should be taught in a high school chemistry course and how it should be taught. In one survey, college chemistry instructors were asked to choose the top five most important topics from high school chemistry that students need to master before taking college chemistry (Deters, 2003). The resulting topics were, in order: basic mathematics skills, the mole concept, dimensional analysis, stoichiometry, and naming compounds and writing formulas. It is important to note that three of the top five topics involve quantitative problem solving rather than any specific chemistry knowledge. In another study, students who mastered stoichiometry in high school chemistry had college chemistry grades that were about one-half of a letter grade higher than students who did not learn stoichiometry in high school (Tai, Ward, & Sadler, 2006).

A previous survey involving both high school and college instructors showed a significant divergence of opinion as to what was essential for students to learn in high school chemistry before taking college chemistry (Mitchell, 1989, 1991). High school
instructors were far more likely to rank chemistry knowledge topics as essential, while college instructors wanted students to have well-developed study and problem-solving skills. College instructors also expected students to enter college chemistry with a set of basic mathematical skills such as graph reading and algebra. Still other college instructors indicated that students would be best served by having a good background in fundamental chemistry concepts as well as a repertoire of basic mathematics capabilities (Stanitski, 2001).

As instructional emphasis in most chemistry courses has shifted toward quantitative problem solving and away from qualitative aspects, a number of chemistry instructors have expressed a need for more attention to descriptive chemistry in these classes. Just as with the CHEM Study project, opinions over the past two decades favor teaching descriptive chemistry in context with appropriate theories and principles (Bent, 1984; Gillespie, 1994; Gillespie & Humphreys, 1993; Gorman, 1983). In a similar manner, opinions regarding an instructor’s approach to laboratory experiments have also been expressed (Stieg, 1988; Tykodi, 1990). By and large, these opinions tend toward inquiry approaches and away from cookbook laboratory exercises.

An instructor’s approach to teaching problem-solving skills is also a key factor in student success in chemistry courses. A number of instructors focus primarily on the problem-solving process, training students to use categorization in order to apply the appropriate algorithm to a problem (Bunce, Gabel, & Samuel, 1991). Students have also been provided multiple problems for practice of specific types of problems (Kotcherlakota & Brooks, 2008; Tai, Ward, & Sadler, 2006). However, it is also widely recognized that such an approach tends to produce students who are skilled in applying
mathematical algorithms to problems but lack the conceptual background to understand why those algorithms are used (Forman, Larreamendy-Joerns, Stein, & Brown, 1998; Mason, Shell, & Crawley, 1997). In order to counteract this tendency, several researchers advocate instructional models that emphasize that conceptual knowledge is the foundation upon which algorithmic problem-solving skills may be built (Sharps, Hess, Price-Sharps, & Teh, 2008; Taasoobshirazi & Glynn, 2009).

A great deal of research data in the above areas relies upon the reliability of teachers to report what is happening in their classroom. Several studies have demonstrated the strength of teacher self-evaluation as a tool for improving instruction (Bennetta, Gräselb, Parchmann, & Waddington, 2005; Humphreys, 1992; Montgomery, 2001). Self-reporting by teachers has also been shown to improve professional development programs for both pre-service (Swain, 2006; Zembal-Saul, Blumenfeld, & Krajcik, 2000) and in-service instructors (Khourey-Bowers & Simonis, 2004; Lucas & Schmitz, 1988; Scantlebury, 2008; Zembal-Saul, Blumenfeld, & Krajcik, 2000). Teacher input and feedback can also be valuable to development of standards-based reform (Shane, Bodner, & Capobianco, 2005) as well as textbooks (Yore, 1991). From these studies, it is apparent that teachers are reliable reporters of classroom activity, and that they make quality recommendations for improvement of their performance and that of their students.

Summary

The theoretical basis for learning chemistry has been described. Since this study examines changes in instruction over time, the progression of both chemistry curriculum and state curriculum standards was discussed. This included the goal of college readiness and its concomitant requirements. A variety of methods for textbook analysis
were described, as well as current knowledge regarding student use of textbooks and students’ perceptions of textbook utility. Finally, teacher perceptions about chemistry content were explored. The accuracy of teacher self-reporting of classroom activities was also confirmed by published research. This wealth of information was then used to design methods by which this study’s research questions may be answered.
CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to examine first-year high school chemistry instruction and materials for evidence of a shift from chemistry as descriptions to chemistry as calculations. To this end, a mixed method research design was employed to permit collection of both quantitative and qualitative data for analysis. Teachers were surveyed as to the topics they include in their high school chemistry instruction. There was provision for open-ended comments or replies on the survey, but interviews with individual teachers provided much more detailed information in support of general survey findings.

Using the survey results to determine topics for which significant differences in coverage were found (based upon the teacher’s years of experience), textbooks were then analyzed for changes to those topics over time. Both content coverage and questions and problems in the text were analyzed and compared. Additional characterization of textbooks included readability levels and textbook friendliness measures. Student utilization of textbooks and its effects on achievement were also examined using archival data from 2000.

Research Questions

Through examination of first-year high school chemistry instruction and materials, what evidence is there, if any, of a shift from chemistry as descriptions to chemistry as calculations from 1985 to 2010?
(1) As reported by high school chemistry teachers, what shifts, if any, have occurred and how have they affected classroom instruction?

(2) For any documented shift noted in part 1, what reasons do high school chemistry teachers give to support concurrent shifts in instruction?

(3) What identified shifts from chemistry as a descriptive science to chemistry as a quantitative science and/or the reverse are documented in chemistry textbooks from 1985-2010?

Methodology Overview

Study Sample: Teachers

Two groups of high school chemistry teachers were surveyed while they were in attendance at professional conferences. The first group was surveyed at Radford University, Virginia, during the ChemEd 09 conference. This resulted in the completion of 81 surveys. The second group consisted exclusively of Texas chemistry teachers who completed a total of 44 surveys while attending the Associated Chemistry Teachers of Texas (ACT\textsubscript{2}) annual luncheon at the Conference for the Advancement of Science Teaching (CAST) in Galveston, Texas, in November 2009. Demographics for both surveyed groups are shown in Tables 2 and 3. While both groups constitute samples of convenience, they also consist of teachers who elect to spend their own time (and frequently their own money) to attend conferences where they can learn how to improve and enhance their chemistry teaching. By attending to their own classroom performance, these teachers are more likely to identify changes in their instruction and were an excellent population to survey for this study because of their documented
desire to improve their approach to teaching chemistry and their willingness to explore new avenues presented by other chemical educators at meetings like CAST.

Table 2

Demographics for Teaching Experience from ChemEd 09 Surveys

<table>
<thead>
<tr>
<th>Experience</th>
<th>0-5 years (%)</th>
<th>6-19 years (%)</th>
<th>20+ years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4 (16%)</td>
<td>12 (31%)</td>
<td>7 (41%)</td>
</tr>
<tr>
<td>Female</td>
<td>21 (84%)</td>
<td>27 (69%)</td>
<td>10 (59%)</td>
</tr>
<tr>
<td>School Setting:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>3 (12%)</td>
<td>9 (23%)</td>
<td>1 (6%)</td>
</tr>
<tr>
<td>Suburban</td>
<td>12 (48%)</td>
<td>18 (46%)</td>
<td>10 (59%)</td>
</tr>
<tr>
<td>Rural</td>
<td>10 (40%)</td>
<td>5 (13%)</td>
<td>4 (23%)</td>
</tr>
<tr>
<td>Mixed</td>
<td>0 (0%)</td>
<td>7 (18%)</td>
<td>2 (12%)</td>
</tr>
<tr>
<td>School Type:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>19 (76%)</td>
<td>31 (79%)</td>
<td>13 (76%)</td>
</tr>
<tr>
<td>Private</td>
<td>4 (16%)</td>
<td>5 (13%)</td>
<td>3 (18%)</td>
</tr>
<tr>
<td>Parochial</td>
<td>2 (8%)</td>
<td>3 (8%)</td>
<td>1 (6%)</td>
</tr>
</tbody>
</table>

Table 3

Demographics for Teaching Experience from CAST 2009 Surveys

<table>
<thead>
<tr>
<th>Experience</th>
<th>0-5 years (%)</th>
<th>6-19 years (%)</th>
<th>20+ years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4 (31%)</td>
<td>3 (16%)</td>
<td>6 (50%)</td>
</tr>
<tr>
<td>Female</td>
<td>9 (69%)</td>
<td>16 (84%)</td>
<td>6 (50%)</td>
</tr>
<tr>
<td>School Setting:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>1 (8%)</td>
<td>2 (10%)</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Suburban</td>
<td>4 (30%)</td>
<td>7 (37%)</td>
<td>4 (33%)</td>
</tr>
<tr>
<td>Rural</td>
<td>7 (54%)</td>
<td>7 (37%)</td>
<td>5 (42%)</td>
</tr>
<tr>
<td>Mixed</td>
<td>1 (8%)</td>
<td>3 (16%)</td>
<td>2 (17%)</td>
</tr>
<tr>
<td>School Type:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>13 (100%)</td>
<td>17 (90%)</td>
<td>12 (100%)</td>
</tr>
<tr>
<td>Private</td>
<td>0 (0%)</td>
<td>2 (10%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Parochial</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>
Texas high school chemistry teachers were also interviewed to add depth and insight to the survey results. Interviewed subjects were recruited at the CAST meeting in November 2009. Following IRB approval for the interview portion of this study (see Appendix A), a total of 14 subjects were interviewed via telephone. Demographics for interviewed teachers are in Table 4.

Table 4

Demographics for Teaching Experience from Texas Teacher Interviews

<table>
<thead>
<tr>
<th>Experience</th>
<th>0-5 years (%)</th>
<th>6-19 years (%)</th>
<th>20+ years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2 (40%)</td>
<td>0 (0%)</td>
<td>1 (20%)</td>
</tr>
<tr>
<td>Female</td>
<td>3 (60%)</td>
<td>4 (100%)</td>
<td>4 (80%)</td>
</tr>
<tr>
<td>School Setting:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>2 (40%)</td>
<td>1 (25%)</td>
<td>1 (20%)</td>
</tr>
<tr>
<td>Suburban</td>
<td>2 (40%)</td>
<td>2 (50%)</td>
<td>2 (40%)</td>
</tr>
<tr>
<td>Rural</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>1 (20%)</td>
</tr>
<tr>
<td>Mixed</td>
<td>1 (20%)</td>
<td>1 (25%)</td>
<td>1 (20%)</td>
</tr>
</tbody>
</table>

(Note: All interviewed teachers taught in public schools.)

Study Sample: Textbooks

Initial selection of textbooks focused on high school chemistry textbooks adopted by Texas in 1987, 1993, and 2002. Two publishers each had a progression of textbook editions with roughly the same authors: Addison-Wesley/Prentice Hall and Holt Rinehart Winston. It was decided to also include textbooks from earlier years as a basis for comparison. Two textbooks from the mid 1960s to mid 1970s were included, one of which was also a Texas adoption. The two textbooks that resulted from post-Sputnik science education reforms were also selected: CHEM Study and CBA. Two even earlier texts from the 1930s were also obtained and included in the analysis as pre-
reform samples. The full list of selected textbooks is shown previously in Table 1 (see Chapter I). No electronic textual material was accessed; physical copies of the books were used for all analyses.

*Study Sample: General Chemistry Students*

Textbook utilization data were collected in spring 2000 in Dr. Mason’s General Chemistry classes at The University of Texas at San Antonio (UTSA). Students completed weekly surveys of textbook usage. From a possible pool of 94 students, 65 turned in at least two-thirds (10 of 15) of the weekly surveys and so were included in the analysis. For the analyzed sample, there were 23 males and 43 females.

**Research Design**

A mixed methods approach was used to collect data. Both quantitative and qualitative data collection were then combined in a concurrent triangulation strategy. This strategy counteracts biases or weaknesses inherent in either approach. It provides methodological triangulation, where the findings from each approach confirm, converge, or corroborate each other. It is a strong research design that produces well-validated outcomes.

For teachers, quantitative data were collected using a pencil-and-paper survey examining content covered by teachers of first-year high school chemistry. Qualitative data collection consisted of responses to an open-ended comment section at the end of the survey as well as transcripts from one-on-one interviews with a smaller group of Texas teachers. Quantitative data for textbooks came from assessing readability and from counting various items like problems or pages for particular topics. Assessing the
friendliness of each textbook provided qualitative data, as a variety of characteristics were rated subjectively on a Likert scale from 1 to 5.

Data Collection Instruments

Teacher Survey

“Exploring Changes in Topic Coverage Made by Teachers of First-year High School Chemistry” is a pencil-and-paper machine-scored survey on which teachers indicated whether or not they covered listed topics in their first-year high school chemistry classes. The survey was approved as Human Subjects Application No. 09-274 by the UNT Institutional Review Board (IRB). A copy of the approved Consent Notice and the IRB approval letter can be found in Appendix A. A copy of the survey can be found in Appendix B.

The list of topics on the survey was modified from the 2009-2010 Advanced Placement Chemistry course outline from the College Board (College Board, 2008). This course outline was used because it contains a wide range of chemistry topics, and so was less likely to have omitted topics taught in different areas of the US. For example, the topic of radioactive decay is in the first-year physics curriculum in Texas and is not listed in the Texas chemistry standards; however, in many parts of the country it is taught as a chemistry topic. The modifications consisted of removing topics that are not normally part of the first-year high school chemistry curriculum.

Teacher Interview Questions

A set of interview questions were developed to elucidate details about changes to topic coverage by teachers in Texas. The survey was approved as Human Subjects Application No. 09458 by the UNT Institutional Review Board (IRB), and the approved
Consent Form and IRB approval letter can be found in Appendix A. Six questions were asked of each interviewee:

(1) Describe a change in instruction that you have observed in your own classroom chemistry teaching.

(2) Why do you think this change took place?

(3) How has this change affected student achievement in your chemistry classes?

(4) How has standardized testing affected what you teach in chemistry?

(5) How has standardized testing affected how you teach chemistry?

(6) Describe a recent interaction that showed you that a student clearly understood a chemistry concept.

Questions 1, 2, and 3 were purposely open-ended to minimize any bias on the part of the researcher. Questions 4 and 5 were asked to differentiate between testing-driven changes and changes that were initiated by the teacher. Question 6 was designed to gain insight into what student behaviors were interpreted by the teacher as comprehension of a concept by a student.

**Textbook Reading Level and Friendliness**

Numerous methods of quantifying the reading level of selected textbooks were considered, but no methods tested gave consistent results when compared. The advice of textbook expert Dr. Rosalind Horowitz, UTSA, was sought to resolve this issue. Textbook reading levels were assessed using the Fry Readability method (Johnson, 1998) as recommended by Dr. Horowitz. However, the vocabulary of chemistry contains many multisyllabic words that tend to inflate the reading level beyond the intended tenth and eleventh grades, so textbook friendliness was also measured as an
alternative method of comparison. A modified version of the Friendly Text Inventory (Singer & Donlan, 1989) was used, assessing items such as organization, discourse consistency, and consistency on a 1-5 Likert scale, where 1 is the lowest rating and 5 is the highest. Some portions of the Inventory were better suited as yes-no items, such as the list of instructional devices. These were scored as 3 for present or 0 for absent. The entire assessment was compiled into a single form that may be examined in Appendix B.

Textbook Assessment of Topic Coverage

A total of five topics came out of the Texas teacher survey with significant differences between teachers with varying levels of classroom teaching experience. For each of these topics, a number of items were measured, such as numbers of pages, illustrations, qualitative questions and quantitative problems. Textbooks were analyzed in random order, in order to eliminate any inadvertent bias toward trends. These values were then compared graphically in chronological order to find any trends in the data. The form used for these analyses is shown in Appendix B.

Textbook Usage by General Chemistry Students

During spring 2000, Dr. Mason used a number of surveys to collect data from her general chemistry students regarding their utilization of the course textbook and other study practices. The initial survey collected demographic data and information about previous mathematics and science courses and past use of high school textbooks. Weekly surveys tracked hours of textbook use, work with lecture notes, and work with peer tutors. A final survey asked for a summary of the semester’s experiences for each
student. Copies of the initial survey, demographic data sheet, weekly surveys, and final survey are also found in Appendix B.

Dependent Variables

Research Question 1

The dependent variables for the first research question are the teachers’ survey responses, including the comments on the open-ended portion of the survey. For each topic, numbers of teachers who have taught each topic and teachers who have never taught each topic were used for subsequent analysis. Comments were coded into different categories for comparison with numerical data from the surveys.

Research Question 2

For this research question, the dependent variables are the responses from the teacher interviews. As qualitative data, the interview transcripts were coded into categories similar to those for the comments on the survey. However, since the focus of the interviews was Texas chemistry teachers, the categories were not identical. They were sufficiently similar for comparison with both the survey results and comments.

Research Question 3

The dependent variables for this research question are the counted items for each topic analyzed in the textbooks. For the textbook use surveys, the dependent variable is the semester grades for the course. Even though letter grades were assigned for the course, numerical grades were used for data analysis.

Independent Variables

For the first two research questions, the independent variables are the teachers who completed the surveys and who participated in the interviews. Specifically, the numbers of years of classroom teaching experience were the most useful data for
comparisons. For the third research question, the independent variables were the textbooks and the topics to be analyzed in each book. Average weekly hours of textbook use was the independent variable in the textbook utilization portion of this study.

Data Analysis

All statistical calculations were carried out using either Microsoft Excel® or a Texas Instruments TI-84 Plus Silver Edition™ calculator. Chi-square comparison is a standard statistical function on this calculator, as are descriptive statistics. All testing for determining statistical significance was based on a test of significance with $\alpha = .05$. Linear least-squares analyses were performed with Excel®.

A chi-square test was used with survey data to compare topics taught between groups of teachers with different levels of classroom experience. Comparisons were also made between Texas teachers and US teachers based upon both sets of survey results. Coded results from qualitative analysis of comments and interview transcripts were reported and compared as percentages.

For textbook analysis, there is no x-axis value to use for linear regression testing, so problem counts by topic were characterized as trends. Linear least-squares analysis was applied to the data from the textbook usage surveys. Results were analyzed by gender and ethnicity as well as the total group.

Summary

Has high school chemistry shifted from teaching chemistry as descriptions to chemistry as calculations? This study was an in-depth examination of the content of first-year high school chemistry courses. Using a concurrent triangulation research
design with mixed methods, quantitative and qualitative data are used to support each other. To assess instruction, teachers completed surveys at two different conferences, and Texas teachers volunteered for one-on-one interviews. Quantitative analysis of survey data was performed in parallel with qualitative analysis of survey comments and interview transcripts (see Appendix C).

A chronological examination of textbook content was also undertaken. Using topics from the surveys, textbooks from as early as 1930 to the present 2002 Texas adoption were analyzed for topic coverage. Textbook usage by college students was also studied, using data collected in 2000 at UTSA. Data were compared in search of correlations between the average weekly hours of student textbook use, student’s perception of textbook usefulness, and the student’s semester course grade.

Taking all the above data in comparison, this study was designed to find evidence in high school instruction and textbooks that accounts for apparent shifts from qualitative to quantitative chemistry, and if the emphasis on the quantitative nature of college freshman chemistry caused students to depend on their textbooks progressively more as the semester continued. If there have been such shifts, then this study was also designed to elucidate reasons for them. Ultimately, knowledge from this study can be used to inform policy decisions regarding chemistry course content and assessment.
CHAPTER IV

RESULTS

Introduction

Having collected data from teachers through the use of surveys and interviews, examination of the data has yielded a much clearer picture of the state of first-year high school chemistry curricula both within Texas and across the United States (US). Textbook data were compared to data from teachers in search of commonalities that describe and explain changes that appear to have been taking place in high school chemistry instruction for the past 25 years. Finally, data regarding student use of textbooks has been examined to assess the impact of textbooks on student achievement in college general chemistry. Combined, the analyzed data sets have provided a clearer and more complete picture of the current state of high school chemistry instruction and of the changes that resulted in the current state.

First Research Question: Shift in Classroom Instruction

Survey Results

Teachers completed surveys at two different professional conferences last fall. The results from the ChemEd 09 surveys were pooled for use as a sample representative of teachers from various points within the United States. Texas teachers’ responses were removed from this data set, as were results from countries outside the US. (ChemEds are international conferences, but teachers from outside the US were excluded from the data analysis.) This resulted in a total of 81 surveys included in this data set. The Conference for the Advancement of Science Teaching (CAST) survey results were pooled for use as the sample of Texas teachers.
Both data sets were separated into groups based upon number of years of experience teaching high school chemistry: 0-5 years, 6-19 years, and 20 or more years. In order to look for the largest shifts in instruction, the groups with five or fewer years of experience were compared with the groups having twenty or more years of experience. In Texas, those with five or fewer years of experience have always taught chemistry to students who are required to pass the Texas Assessment of Knowledge and Skills (TAKS) in science in order to graduate from high school. Texas chemistry teachers who have 20 or more years of experience began teaching chemistry prior to the implementation of any statewide tests (in any subject areas) that students were required to pass in order to graduate. This meant that these teachers were able to set up their lesson plans based upon school district curricula or their own expertise with chemistry. Since most school district curricula were written by experienced teachers in each subject area, even prescribed curricula were based upon the same general expectations and goals for what students learned during the course. So more experienced chemistry teachers established their scope and sequence details without any administrative pressure for success on a high-stakes test.

The chi-square comparisons of topic coverage between inexperienced and experienced US teachers revealed statistically significant differences for only two topics of the 58 topics analyzed: structures of solids and oxidation numbers. Interestingly enough, it was the inexperienced US teachers who covered these topics more often than experienced US teachers; the difference in proportions is significant for structures of solids, $\chi^2 (1, N = 42) = 6.434, p < .05$, and for oxidation numbers, $\chi^2 (1, N = 41) = 4.570, p < .05$. No significant differences were observed for these two topics with Texas
teachers. An examination of the survey results for US teachers indicates that one of the topics in question (structures of solids) is descriptive while the other (oxidation numbers) involves calculations. Apparently, omission of topics by more experienced US chemistry teachers was not decided by the amount of calculations necessary.

The same comparisons of Texas teachers for the 58 topics as listed on the survey (see Appendix B) yielded statistically significant differences for five topics: deviations from ideal gas laws; standard half cell electrochemical potentials; balancing oxidation-reduction (redox) equations; heats of vaporization and fusion; and calorimetry. In each case, significantly more of the experienced Texas teachers covered the topics while the inexperienced Texas teachers did not. For US teachers, there were no significant differences, as shown in Table 5:

Table 5

*Results of Chi-Square Analysis of Teacher Survey Results*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Texas (20+ &gt; 0-5 years)</th>
<th>US (no differences)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( N^* )</td>
<td>( \chi^2 )</td>
</tr>
<tr>
<td>Deviations from ideal gas laws</td>
<td>25</td>
<td>10.860**</td>
</tr>
<tr>
<td>Standard half-cell potentials</td>
<td>25</td>
<td>6.997**</td>
</tr>
<tr>
<td>Balancing redox equations</td>
<td>25</td>
<td>4.427**</td>
</tr>
<tr>
<td>Heats of vaporization and fusion</td>
<td>23</td>
<td>6.135**</td>
</tr>
<tr>
<td>Calorimetry</td>
<td>24</td>
<td>5.344**</td>
</tr>
</tbody>
</table>

(*\( N \) not equal due to not every respondent answering every survey item)
(**\( p < .05 \))

Further review of survey results shows that, for Texas teachers, two of the topics of interest are descriptive in nature (deviations from ideal gas laws; heats of
vaporization and fusion), while the other three involve more rigorous mathematical problem solving. Deviations from ideal gas laws are covered at the conceptual level even in Advanced Placement (AP) chemistry; while AP chemistry students may be exposed to the van der Waals equation for non-ideal gases, they do not perform any calculations with it. The concept of heats of fusion and vaporization are discussed with substance heating and cooling diagrams, but the numerical values are not used until calorimetric calculations require them. It appears that whether or not a topic is descriptive or quantitative was not relevant to inexperienced Texas teachers' decisions to omit it.

What all these topics do have in common is that they are not tested on the science TAKS. With administrative pressure to maintain passing scores and higher ratings, it is not surprising that less experienced teachers are omitting these topics from their instruction. Newer teachers have not taught chemistry without having to deal with TAKS, and they are far more susceptible to pressure from principals and other administrators. More experienced teachers, on the other hand, have clearer ideas of what needs to be included in a college-preparatory chemistry course and refuse to omit concepts from that curriculum.

Survey Comments

Qualitative analytical techniques were used to evaluate teacher responses to the open-ended survey questions. Four themes were evident as the comments were reviewed:

(1) states' impact on course content, either through required curriculum or course requirements for graduation
(2) student behaviors and abilities, such as lack of mathematics skills or poor attitudes about learning

(3) issues with the existing curriculum, described as concerns about depth of material being presented and recent emphasis on inquiry methods of learning chemistry

(4) concerns about tools, such as lack of equipment or consumable supplies for labs and the inclusion of technology into classroom and lab activities.

A total of 74 comments were noted on the ChemEd 09 surveys. Almost half of these comments dealt with curriculum issues. Several teachers used the term “watering down” to describe changes they have seen in chemistry education. One teacher with 20 or more years of experience expressed this concern:

When I first started teaching I did not cover as much information but what I did cover, I did in depth. Now I feel that I cover a lot but they don’t know it as well.

The increase in inquiry as a teaching and learning strategy was also noted by a number of teachers and is in support of the goal of the National Science Education Standards (NSES) to teach science as a process (National Research Council, 1996). As pointed out by another experienced teacher, “Why and how have changed more than what is taught.”

The remainder of comments was evenly divided between the other three categories listed above. Most teachers who made comments about state rules or regulations cited state-mandated tests as an area of concern. Eight comments specifically referenced loss of class time to test preparation activities and the concomitant loss of content from the chemistry curriculum. One less experienced teacher expressed this succinctly: “Only cover material covered by state test.” Still another criticized their state’s tests as “a disgrace!”
Comments about students centered on motivation or lack of mathematical or problem-solving skills needed in chemistry class. Several blamed the lack of mathematical skills on use of calculators while others pointed out that state graduation requirements making chemistry a mandatory course has also factored into this concern. State testing also played into students’ lack of motivation, as it was noted that students only want to learn what is on the test, and they consider chemistry class to be finished after the state tests even if there are still several weeks of the school year left.

As seen in Table 7, comments from the CAST 09 surveys were distributed similarly to the ChemEd 09 comments, except that far fewer teachers mentioned tools (technology or lab supplies) on the Texas survey. They also expressed the same concerns and issues as the US teachers with regard to inquiry, student motivation, and students’ lack of mathematical abilities. However, comments about the state tests were more pointed, as indicated by this teacher:

Emphasis has moved toward passing TAKS (Texas Assessment of Knowledge and Skills) test. I’ll be glad to go back to studying chemistry for chemistry’s sake!

Table 6

*Distribution of Comments from Teacher Surveys from ChemEd 09 and CAST 2009*

<table>
<thead>
<tr>
<th>Comment Category</th>
<th>US Responses (out of a total of 74 comments)</th>
<th>TX Responses (out of a total of 30 comments)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>13 (17.6%)</td>
<td>7 (23.3%)</td>
</tr>
<tr>
<td>Students</td>
<td>12 (16.2%)</td>
<td>7 (23.3%)</td>
</tr>
<tr>
<td>Curriculum</td>
<td>35 (47.3%)</td>
<td>14 (46.7%)</td>
</tr>
<tr>
<td>Tools</td>
<td>14 (18.9%)</td>
<td>2 (6.7%)</td>
</tr>
</tbody>
</table>
Second Research Question: Causes of Instructional Shift in Texas

Interview Results

The most insight into chemistry teaching issues and concerns was gained through one-on-one interviews with a group of 14 Texas teachers. When asked to cite their biggest change in chemistry instruction, 12 of the 14 teachers said that the TAKS program has changed the course significantly or completely. Many stated that they are expected to teach “TAKS science” not just chemistry, especially in the weeks prior to test administration. It is important to note here that 60% of the science TAKS covers biology, while 20% is devoted to chemistry and the remaining 20% to physics and that the chemistry and physics TEKS addressed are at the IPC (integrated physics and chemistry) level. Consequently, many teachers reported having to either re-teach or review biology during time when they would otherwise be teaching chemistry. One teacher with two years of classroom experience described it this way:

I consider myself to be a chemistry teacher, and that’s what my title says, but I find that most of the year I end up teaching biology and teaching physics, because we have to review for the exit level (test). We have to leave out some of the material in chemistry in order to get to all the TEKS (Texas Essential Knowledge and Skills) for TAKS.

Most of the required TAKS reviews are mandated by the teacher’s school or district. Some districts have requirements such as “TAKS folders” and multiple benchmark tests, all of which take up chemistry class time. Some teachers report that teaching chemistry content that is not on the TAKS will earn them an administrative reprimand:

I sneak in what I think is important—that is not high-stakes tested—when I can. And when I know I won’t get caught doing it. But otherwise, if it’s not a testable objective, they wanna know why am I doing it in my classroom.
When asked about student achievement in chemistry, most teachers indicated that they haven’t really seen changes in students’ grades. However, several made specific reference to standards being lowered to teaching that which is tested:

I think the grades have not been affected so much because we have lowered the curriculum standards.

I don’t know if it’s because of emphasis on TAKS, but it seems to me that we’re shooting at mediocrity in our school.

When asked to describe an interaction with a student that demonstrated real comprehension of a chemistry concept, most teachers referred to observing students in peer tutoring situations. In each of these cases, the teacher was just an observer as one student would re-explain something to another student who didn’t understand it. All these teachers expressed pleasure that their students not only understood a concept themselves but were also willing to help their classmates understand it. It was noted by several teachers that in these situations, students actually came up with better examples of a concept that the teacher had never considered. Overall, this indicates that most teachers have similar standards for what “student understands” means in an operational sense.

The most striking difference between the survey comments and interview transcripts is the repeated mention of administrative pressure for students to pass the science TAKS test. The usual outcome of this focus on testing over content is a reduced chemistry curriculum for students. However, it should be noted that the most experienced Texas teachers are not changing what content they teach. Several interviewees stated outright that they have not taken anything out of their course
because students will be expected to know these concepts and skills in college. Indeed, one reported feedback from alumni students:

They actually, when I've had students go to college, they come back and say, “Don’t change what you’re teaching—we use this in college.”

The attitude expressed here by the most experienced chemistry teachers with regard to leaving material in their courses confirms observations of the same phenomenon in the Texas surveys. It is the likely reason for the significant difference in topic coverage between the most and least experienced Texas chemistry teachers.

Third Research Question: Shift in Textbook Content

Textbook Analysis

The initial step in textbook analysis, establishing the reading level and text friendliness, showed that most textbooks were within two years of each other with regard to Fry readability, as shown in Table 7. The upward trend in text friendliness is due to enhancements in printing processes, which allowed more of the “friendly” items to be included, such as margin notes, graphic devices, and glossaries.

Using the five topics from the Texas survey listed above, 14 high school chemistry textbooks were then analyzed for topic coverage. Since the focus of this study was chemistry as descriptions as compared to chemistry as calculations, the data discussed here will pertain to the numbers of qualitative questions and problems as compared to quantitative questions and problems. In general, there is a trend for more recently published textbooks to contain more quantitative problems than qualitative problems. More recent textbooks also tend to have more questions and problems overall.
Table 7

Fry Readability Levels and Textbook Friendliness Scores for Selected Chemistry Textbooks

<table>
<thead>
<tr>
<th>Textbook</th>
<th>Year Publ.</th>
<th>Friendliness</th>
<th>Fry Readability (Grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>McPherson</td>
<td>1930</td>
<td>151</td>
<td>11</td>
</tr>
<tr>
<td>Bradbury</td>
<td>1934</td>
<td>139</td>
<td>10</td>
</tr>
<tr>
<td>CHEM Study</td>
<td>1963</td>
<td>153</td>
<td>12</td>
</tr>
<tr>
<td>CBA</td>
<td>1964</td>
<td>158</td>
<td>14</td>
</tr>
<tr>
<td>Garrett</td>
<td>1966</td>
<td>134</td>
<td>11</td>
</tr>
<tr>
<td>Smoot*</td>
<td>1971</td>
<td>144</td>
<td>13</td>
</tr>
<tr>
<td>Holt 1986*</td>
<td>1986</td>
<td>166</td>
<td>15</td>
</tr>
<tr>
<td>Holt 1993*</td>
<td>1993</td>
<td>170</td>
<td>15</td>
</tr>
<tr>
<td>Holt 2002*</td>
<td>2002</td>
<td>172</td>
<td>12</td>
</tr>
<tr>
<td>AdWes 2nd*</td>
<td>1987</td>
<td>163</td>
<td>13</td>
</tr>
<tr>
<td>AdWes 3rd*</td>
<td>1993</td>
<td>172</td>
<td>10</td>
</tr>
<tr>
<td>AdWes 4th</td>
<td>1997</td>
<td>176</td>
<td>10</td>
</tr>
<tr>
<td>AdWes 5th</td>
<td>2000</td>
<td>173</td>
<td>13</td>
</tr>
<tr>
<td>AdWes 6th*</td>
<td>2002</td>
<td>170</td>
<td>10</td>
</tr>
</tbody>
</table>

*Texas-adopted textbooks

There is no correlation between numbers of problems and years of publication for the examined textbooks. However, when presented graphically, it is easy to see the general upward trend for number of both types of problems, as in Figures 1-5. The comparison of numbers of qualitative to quantitative problems is also shown in each graph.
The data presented in Figures 1-5 indicate that there has been a shift from qualitative questions to quantitative problems in high school chemistry textbooks. However, it is not always a uniform shift, even within one textbook series. It is also important to note the progression of technology as shown in these textbooks. In the 1993 and 2002 editions of Holt *Modern Chemistry*, there are sections included which instruct students in the use of Texas Instruments (TI) graphing calculators in chemistry class and lab. The 4th, 5th, and 6th editions of the Addison-Wesley/Prentice Hall *Chemistry* textbook also contain this type of section. Since facility with TI graphing calculators is a required skill for the exit-level mathematics TAKS, these textbook sections facilitate transfer of concepts and skills from mathematics to chemistry.

![Deviations from Ideal Gas Laws](image)

*Figure 1.* Comparison of textbooks: Deviations from ideal gas laws problems.
Figure 2. Comparison of textbooks: Standard half-cell potentials problems.

Figure 3. Comparison of textbooks: Balancing redox equations problems.
Figure 4. Comparison of textbooks: Heats of fusion and vaporization problems.

Figure 5. Comparison of textbooks: Calorimetry problems.
Analysis of textbooks also reveals that all topics that less experienced teachers tend to omit from instruction are still covered. It appears that tested TAKS content and administrative pressure, and not changes in textbook content or problems, are the driving force behind content omissions by less experienced teachers.

Textbook Usage

For this analysis, average number of hours per week of textbook use was compared to final course grades and to student rating of textbook usefulness for 65 students in general chemistry at The University of Texas at San Antonio in spring 2000. Of this total, 42 were female and 23 were male. Seventeen identified their ethnicity as White, non-Hispanic (12 female and 5 male), and 24 identified their ethnicity as Hispanic (15 female and 9 male). Other ethnicities were reported by 5 or fewer students, and 12 students did not report their ethnicity. Linear least-squares analysis on the total sample of 65 students indicated that there is no correlation between weekly text use hours and final course grades ($r = .2484$, $r^2 = .0617$) or between perceived textbook usefulness and final course grades ($r = .1634$, $r^2 = .0267$). There is a small correlation between perceived textbook usefulness and weekly hours of textbook use ($r = .4658$, $r^2 = .2170$). This is logical, as a student who finds the textbook more useful will likely use it for more hours during the week. It also suggests that students’ survey replies are reasonably accurate. In fact, this correlation was found for every subgroup analyzed, as shown in Table 8.
Table 8

Comparison of Hours of Textbook Use with Student Perception of Textbook Usefulness

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>n</th>
<th>R</th>
<th>$r^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>42</td>
<td>.3977</td>
<td>.1582</td>
</tr>
<tr>
<td>Males</td>
<td>23</td>
<td>.5325</td>
<td>.2836</td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>17</td>
<td>.6008</td>
<td>.3610</td>
</tr>
<tr>
<td>White, non-Hispanic Females</td>
<td>12</td>
<td>.5375</td>
<td>.2889</td>
</tr>
<tr>
<td>White, non-Hispanic Males</td>
<td>5</td>
<td>.7099</td>
<td>.5039</td>
</tr>
<tr>
<td>Hispanic</td>
<td>24</td>
<td>.5388</td>
<td>.2903</td>
</tr>
<tr>
<td>Hispanic Females</td>
<td>15</td>
<td>.4308</td>
<td>.1856</td>
</tr>
<tr>
<td>Hispanic Males</td>
<td>9</td>
<td>.6020</td>
<td>.3624</td>
</tr>
</tbody>
</table>

For other comparisons, there are correlations for several subgroups. A small correlation was seen between weekly text use hours and final course grades for male students ($r = .4773$, $r^2 = .2278$), with 23% of the variability of course grades resulting from average weekly hours of textbook usage. This is also true for Hispanic males, albeit to a lesser degree ($r = .3504$, $r^2 = .1228$). Between final course grades and perceived usefulness of textbook, correlations exist for White, non-Hispanics ($r = .3292$, $r^2 = .1084$) and for Hispanic males ($r = .4408$, $r^2 = .1943$). For all other comparisons, no correlations were found.

Since there is little correlation between either hours of textbook use or perceived textbook usefulness and final course grade, it is unlikely that textbook usage by high school students will affect their course grades or overall comprehension of chemistry. It is important to note here that this study needs to be repeated with high school students, and these data need to be much more recent in order for the conclusions from the 2000 study to apply to high school students being affected by the studied changes in instruction and textbook content.
Summary

For most of high school chemistry in Texas and the US, there are no significant differences in what is being presented by teachers, regardless of their level of chemistry teaching experience. The only differences seen for US teachers are that less-experienced US teachers report covering structure of solids and oxidation numbers significantly more often than do more-experienced US chemistry teachers. In Texas, however, significant differences between teachers with 0-5 years experience and 20 or more years of experience were observed for five topics. These differences were not observed for US teachers, so the difference is due to something happening in Texas chemistry classrooms that is not happening elsewhere in the country.

Comments from teacher surveys and Texas teacher interviews showed that concerns regarding curriculum issues are the most commonly reported. Issues with time lost to test preparation and broader but shallower content are common to teachers in Texas and the US, as are concerns with student skills and motivation. However, Texas teachers reported more intervention and stress from school administrators over achievement on the science TAKS than did US teachers.

Since 1985, publishers have generally increased the number of quantitative problems and the ratio between quantitative and qualitative problems as they have continued to increase the total number of problems presented in chemistry textbooks. Although there is no correlation between publication year and number of problems, graphical analysis shows the generally increasing trend for the significant topics from the Texas teacher survey. Since the content is consistently present in all examined textbooks since 1985, it is reasonable to conclude that textbooks are not the driving
force behind curricular changes indicated on the teacher surveys. Additionally, no correlation was seen between general chemistry students’ amount of textbook usage or reported textbook usefulness and their final course grade, so it appears that time students spend with their textbook is not governing student achievement in chemistry.

What has become apparent from the data is that the main reason chemistry instruction has changed in Texas is a direct result of the content of the science TAKS. Added to that is the pressure that administrators place on teachers and students to make passing scores on this test. The result is loss of instruction on a variety of topics, and students who took those courses in high school arrive at college without concepts that most professors expect them to have learned in high school. They are proficient at mathematical problem solving because that is a required skill on the mathematics TAKS. So college general chemistry ends up with students who are very capable with algorithmic problem solving but who are deficient in some basic chemistry concepts, as has been observed in the past (Mason, Shell, & Crawley, 1997).

Will this situation change? It should, since the SBOE adopted new TEKS in chemistry in spring 2009. The new TEKS add depth to the old objectives, and pushes students and teachers to meet college readiness standards for chemistry. What motivation do teachers have to change their instruction using the new TEKS? The SBOE has replaced exit level TAKS with a collection of end-of-course (EOC) STAAR exams that are specific to each course taught and are mandated to determine 15% of the students' final grades. While the transition to use of EOCs will probably be painful for some teachers and students, after they are fully implemented in 2015, students
should be bringing a stronger chemistry conceptual background with them to college general chemistry.
CHAPTER V
CONCLUSION

Success in college chemistry depends upon a student’s ability to understand chemistry concepts as well as their competence with mathematical problem solving. It has been observed by a number of college chemistry instructors that students enter their courses with a much better foundation in algorithmic problem solving than in fundamental concepts of chemistry. This observation is somewhat supported by the reported means by the American Chemical Society Division of Chemical Education composite norms of the 1997 California Chemistry Diagnostic Exam that is given to students entering their study of chemistry at the post-secondary level. Of the 44 questions on the average only 20.45 are correctly answered with a standard deviation of 7.56 (http://chemexams.chem.iastate.edu/stats/norms/cd97.cfm). Since almost all public school students in Texas are required to take first-year high school chemistry in order to graduate, these students have been exposed to many chemistry concepts that are addressed in college general chemistry courses. However, their performance on conceptual chemistry exam questions tends to be weak, while they have little difficulty with solving mathematical chemistry problems. The mean of 1328 entering general chemistry students at the University of North Texas on the California Diagnostic Exam is consistent with the national norm being 20.30 ($sd = 7.77$). Even when conceptual questions are paired with mathematical problems, students may not understand the basic chemistry beneath the calculations they carry out on problems (Mason, Shell, & Crawley, 1997). There is obviously no statistically significant difference in these two
means, but how do educators address the lack of student college readiness in chemistry?

The Texas Essential Knowledge and Skills (TEKS) (TEA, 2009b) cover a wide range of basic chemistry concepts, and have recently been revised with more emphasis on quantitative problem solving. Even though teachers are required to teach the TEKS for their courses, there is no direct accountability for that responsibility. Teacher evaluations are snapshots in time, one class period long, and were never designed to assess TEKS coverage throughout an entire school year. In an effort to find out what has been happening in high school chemistry classes both in Texas and across the United States (US), teachers have been asked, “What are you actually teaching in your first-year chemistry course?”

There has been only one other such survey published (Deters, 2006), but its goal was to ascertain the levels at which surveyed teachers covered topics usually included in first-year high school chemistry courses. The surveys reported here were structured in a similar manner, but the data analysis was different. This dissertation study used survey results as a basis for comparison between teachers from Texas and from the US, and to compare teachers with different levels of classroom experience. The previous study made no comparisons between teachers with different levels of experience, nor did it examine responses of teachers grouped by state.

Perhaps the largest difference between the studies is that topics normally considered part of oxidation-reduction reactions and their applications were not included on the previous survey. For this study, inclusion of these topics served to magnify the
differences between more and less experienced teachers in Texas. It would have been interesting to see how these topics fared on the previous survey.

In addition to specifically recruited participation by the Associated Chemistry Teachers of Texas (ACT\textsubscript{2}), what the two studies have in common is found in the open-ended comments on both surveys. These similarities are also reflected in the teacher interviews in this study. Areas of common concern include: curricular breadth versus depth, accountability and testing taking away from teaching chemistry, student weaknesses in mathematics, and requiring all students to follow a college-preparatory curriculum despite the reality that not every student is college-bound.

This study has also shown that, for less experienced teachers who are under administrative pressure for better scores, the implementation of a high-stakes test has definitely narrowed the curriculum to that which is tested. This phenomenon was described previously (Kohn, 2000) and has been observed more recently by other researchers (Shane, Bodner, & Capobianco, 2005). In the Shane study, similar tendencies (of less-experienced Indiana teachers) to compromise course content in pursuit of higher test scores were noted. As was seen in the Texas results, more experienced teachers were less willing to make such compromises as it hindered their larger goals of accurate portrayal of science as a process and to promote in-depth understanding of a smaller number of scientific concepts.

A case study of a fifth-grade science and mathematics teacher with 37 years of teaching experience found that this teacher made decisions that would cover material to help her students pass their fifth-grade TAKS exams, but did so without compromising the content of her instruction (Kessler & Kamen, 2005). The researchers characterized
this teacher’s response to testing pressure as positive, which agrees with both survey comment and interview responses from experienced teachers.

Where the current survey differs is in the generation of quantitative data that indicate statistically significant differences between teachers with different levels of teaching experience. However, without the dimension added through the collection of qualitative data through teacher interviews, the root cause of the quantitative findings would not be nearly so obvious.

Analysis of high school chemistry textbooks has shown that textbooks in use since 1985 have, for the most part, maintained their content coverage. Even for Texas-adopted textbooks, concepts missing from the Texas Essential Knowledge and Skills (TEKS) for chemistry remained in the texts. As expected, in concert with advances in calculator technology, the number of quantitative problems for each topic has tended to increase, as has the total number of problems in general. The number of qualitative questions and problems has also increased, but generally not at the same rate as the quantitative problems.

Examination of student use of textbooks in a college general chemistry course showed that there is very little correlation between the amount of time a student uses their textbook and their final course grade. This is also true for a student’s rating of their textbook’s usefulness and their final course grade. Not surprisingly, there is a partial correlation between how useful a student thinks their textbook is and the amount of time that student actually uses their textbook. However, neither time of use nor usefulness of the course textbook has any measurable effect on a student’s final course grade in
Answering the Research Questions

Through examination of first-year high school chemistry instruction and materials, what evidence is there, if any, of shifts from chemistry as descriptions to chemistry as calculations from 1985 to 2010?

(1) As reported by high school chemistry teachers, what shifts, if any, have occurred and how have they affected classroom instruction?

Answer: Survey results indicate that less experienced Texas chemistry teachers tend to omit content that is not tested on the science TAKS. More experienced Texas teachers tend not to omit untested concepts from their chemistry instruction. Surveys from teachers in other states do not reflect these differences. The omitted topics are both qualitative and quantitative, so there appears to be no overall shift from qualitative to quantitative chemistry indicated by Texas survey results.

(2) For any documented shift noted in part 1, what reasons do high school chemistry teachers give to support concurrent shifts in instruction?

Answer: Both comments from Texas teacher surveys and information gained through Texas teacher interviews cited high-stakes testing as the main driving force behind many teachers’ curricular decisions in Texas. Although teachers from other states had similar concerns, there was no overall reflection of changes in instruction due to implementation of standardized testing on a national basis.
(3) What identified shifts from chemistry as a descriptive science to chemistry as a quantitative science and/or the reverse are documented in chemistry textbooks from 1985-2010?

Answer: The total numbers of problems in textbooks is generally increasing. Both qualitative and quantitative questions and problems have increased in number, but the numbers of quantitative problems appear to be increasing more than are the qualitative ones. Problems involving calculations have increased as students have had more access to calculators in the classroom, and most current textbooks contain materials specifically addressing calculator use in chemistry classes. However, this study indicates that there is no correlation between the time a student spends using their chemistry textbook and the student’s final course grade, so changes in classroom instruction likely have much more bearing on the concepts students learn in high school chemistry.

From the results of this study, it appears that Texas students with less experienced teachers are likely to miss instruction in chemistry concepts that are not on the science TAKS. Even though the majority of Texas high school graduates have credit for a year of chemistry, a fair number bring with them a limited amount of conceptual chemistry knowledge to apply to their college-level chemistry courses. Texas high school graduates are required to have facility with graphing calculators, as that is required to pass the mathematics TAKS. Combined, these two findings explain how so many general chemistry students can solve mathematical chemistry problems but have little understanding of the underlying chemistry taking place in the problems.
Suggestions for Future Research

There are a number of directions in which to extend this study. First, there are a number of states that also have high-stakes tests for chemistry. The teacher survey and interview portions of this study could be replicated to find out if conditions in other states are similar to those in Texas. Chemistry tests from different states could also be compared for content, as could the effects of administrative management of testing and school ranking.

In five or more years from now, this study could be repeated to explore changes that result from the new TEKS and STAAR exams. It is hoped that chemistry teachers of all levels of experience would no longer be compelled to omit content, since it should be tested on the chemistry end-of-course exam. The impact of the new exam on student achievement in chemistry is another topic of future interest, as is the investigation of the effects of the new exams on student performance in college-level chemistry courses. However, it may be ten years or more before college chemistry professors notice any changes in their students’ performance. As high school chemistry textbooks currently cover most of the new TEKS, there should be little change in their content in the near future.

A topic of discussion at various levels of education is the evolution from hard-copy textbooks to open textbooks. Open textbooks are available in various digital formats, greatly reducing the expense of traditional textbook purchase. By their very nature, open textbooks respond much more quickly to changes in chemistry information and research. It can take ten years or more for new knowledge generated through
laboratory research to find its way into traditional textbooks. Open textbooks are also easily customized for different educational settings or different instructors.

For the past eleven years, Rice University has had an online repository called Connexions that facilitates the use of open textbooks under the Creative Commons Attribution license (Baker, Thierstein, Fletcher, Kaur, & Emmons, 2009). The Creative Commons is, in their words, “a nonprofit organization that works to increase the amount of creativity (cultural, educational, and scientific content) in “the commons” — the body of work that is available to the public for free and legal sharing, use, repurposing, and remixing” (Creative Commons, 2010). The Massachusetts Institute of Technology (MIT) has a large open courseware website that operates under a Creative Commons license (Massachusetts Institute of Technology, 2010).

Following examples such as these, it is only a matter of time before public schools across the country embrace the open textbook concept. For Texas, which purchases textbooks for its public school students, the cost savings could be enormous. Currently, the main obstacle to statewide adoption of open textbooks is the hardware needed to access them. However, the necessary technology continues to become less expensive, so at some point moving to open textbooks will likely be a way for Texas to spend less on instructional materials while getting access to far more knowledge than ever before. That will add much more importance to curricular decisions made by chemistry teachers as they develop these resources for classroom use. This melding of teachers and textbooks into open textbooks and courses should provide many opportunities to conduct studies similar to this one.
One last suggestion for future research into this area involves surveying and interviewing high school students with regard to textbook usage, chemistry course content, and impacts from standardized testing. While high school students may appear to many teachers and administrators as simply the recipients of knowledge, they are also heavily invested in the processes through which their learning proceeds. It will be interesting to involve them in the research of their own education.
APPENDIX A

IRB APPROVALS AND CONSENT FORMS
July 8, 2009

Kathleen Holley  
Department of Chemistry  
University of North Texas

RE: Human Subjects Application No. 09-274

Dear Ms. Holley:

In accordance with 45 CFR Part 46 Section 46.101, your study titled “Exploring Changes in First-year High School Chemistry Topic Coverage by Teachers” has been determined to qualify for an exemption from further review by the UNT Institutional Review Board (IRB).

No changes may be made to your study’s procedures or forms without prior written approval from the UNT IRB. Please contact Jordan Smith, Research Compliance Assistant, ext. 3940, if you wish to make any such changes. Any changes to your procedures or forms after 3 years will require completion of a new IRB application.

We wish you success with your study.

Sincerely,

Patricia L. Kaminski, Ph.D.  
Associate Professor  
Chair, Institutional Review Board

PKjs

CC: Dr. Diana Mason
Informed Consent Notice

The purpose of this research study is to explore changes in topic coverage made by teachers of first-year high school chemistry courses. You are being asked to complete a survey that will take 15-20 minutes. Answering the questions in the survey involves no foreseeable risks. Participation is voluntary and you may stop at any time without penalty. By completing the survey you are giving consent to participate and confirming that you are at least 18 years old. Results of the survey will be reported only on a group basis.

If you have any questions regarding this study, please contact Dr. Diana Mason at dmason@unt.edu or by phone at 940-565-2491. This project has been reviewed and approved by the University of North Texas Institutional Review Board (940) 565-3940. Contact the UNT IRB with any questions regarding your rights as a research subject. You may keep this Notice for your records.

Demographic information: Please complete the following items. Where appropriate, fill in one digit at the top of each column and bubble it in.
Gender (female, male)
Age (write in age and bubble in—two-column “grid-able” data entry)
Type of school (public, private, parochial) and (rural, suburban, urban, mix)
Location of school (city, state, country)
Number of years experience teaching first-year high school chemistry (write in years and bubble in—two-column “grid-able” data entry)
At your school, must students pass high stakes tests in order to graduate? (yes, no)
If yes, have these tests affected the course content in first-year chemistry? (not at all, a few changes, a moderate number of changes, a large number of changes, changed the course completely)

Directions:
Below are a number of topics commonly addressed in first-year high school chemistry courses. Please mark the appropriate column(s) for each subtopic. Once you have completed the survey, you will have the opportunity to make additional comments.

Thank you very much for your input!
IRB Approval Letter for Teacher Interviews

November 20, 2009

Kathleen Holley
Department of Chemistry
University of North Texas

RE: Human Subjects Application No. 09458

Dear Ms. Holley:

In accordance with 45 CFR Part 46 Section 46.101, your study titled “Teacher Interviews Exploring Changes in First-year High School Chemistry Instruction” has been determined to qualify for an exemption from further review by the UNT Institutional Review Board (IRB).

Enclosed is the consent document with stamped IRB approval. Please copy and **use this form only** for your study subjects.

No changes may be made to your study’s procedures or forms without prior written approval from the UNT IRB. Please contact Shelia Bourns, Research Compliance Administrator, ext. 3940, if you wish to make any such changes.

We wish you success with your study.

Sincerely,

Patricia L. Kaminski, Ph.D.
Associate Professor
Chair, Institutional Review Board

PK: sb

CC: Dr. Diana Mason
University of North Texas Institutional Review Board

Informed Consent Form

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

Title of Study: Teacher Interviews Exploring Changes in First-year High School Chemistry Instruction.

Principal Investigator: Kathleen Holley, a graduate student in the University of North Texas (UNT) Department of Chemistry.

Purpose of the Study: You are being asked to participate in a research study to examine perceptions and motivations of high school chemistry teachers with regard to changes in instruction in their classrooms.

Study Procedures: You will be asked to complete one telephone interview with Kathleen Holley. This will take about 15-20 minutes of your time.

Foreseeable Risks: No foreseeable risks are involved in this study.

Benefits to the Subjects or Others: This study is not expected to be of any direct benefit to you. However, the results of this study will be combined with the results of a previously administered survey to develop a more complete picture of changes that chemistry teachers see in their own instruction. This picture, in turn, may very well serve as a reference for making future changes in teaching high school chemistry.

Procedures for Maintaining Confidentiality of Research Records: The confidentiality of participant information will be maintained in any publications or presentations regarding this study as well as the doctoral dissertation. Kathleen Holley will be the only person with access to the original interview audio files. Interviews will be transcribed to a MS Word document for further analysis. Data files to be analyzed will be generated from interview transcripts. Digital interview files and copies of transcripts and data files will be stored in a locked office/cabinet in Dr. Diana Mason’s office in SRB 240 at UNT for a minimum of three years after the completion of the study. No names or personal information will be given out as a result of this study.

Questions about the Study: If you have any questions about the study, you may contact Kathleen Holley at telephone number or the faculty advisor, Dr. Diana Mason, UNT Department of Chemistry, at telephone number 940-565-2491.

Review for the Protection of Participants: This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT
IRB can be contacted at (940) 565-3940 with any questions regarding the rights of research subjects.

**Research Participants’ Rights:** Your participation in an interview indicates that you have read or have had read to you all of the above and that you confirm all of the following:

- Kathleen Holley has explained the study to you and answered all of your questions. You have been told the possible benefits and the potential risks and/or discomforts of the study.
- You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits. The study personnel may choose to stop your participation at any time.
- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant and you voluntarily consent to participate in this study.
- You have been told you may print out a copy of this form.

Approved by the UNT IRB
FROM 11/20/09 TO 11/19/10

Office of Research Services
University of North Texas
Last Updated: August 9, 2007
APPENDIX B

DATA COLLECTION INSTRUMENTS
Exploring Changes in Topic Coverage Made by Teachers of First-year High School Chemistry

The purpose of this research study is to explore changes in topic coverage made by teachers of first-year high school chemistry courses. You are being asked to complete a survey that will take 15-20 minutes. Answering the questions in the survey involves no foreseeable risks. Participation is voluntary and you may stop at any time without penalty. By completing the survey, you are giving consent to participate and confirming that you are at least 18 years old. Results of the survey will be reported only on a group basis.

If you have any questions regarding this study, please contact Dr. Diana Mason at dmason@unt.edu or by phone at (940) 565-2491. This project has been reviewed and approved by the University of North Texas Institutional Review Board (940) 565-3940. Contact the UNT IRB with any questions regarding your rights as a research subject. You may keep this Notice for your records.

Demographic Information: Please complete the following items. Where appropriate, fill in one digit at the top of each column and bubble in the appropriate number.

Age: [ ] Number of years [ ]

- 0 [ ]
- 1 [ ]
- 2 [ ]
- 3 [ ]
- 4 [ ]
- 5 [ ]
- 6 [ ]
- 7 [ ]
- 8 [ ]
- 9 [ ]

Gender: [ ] Male [ ] Female

- Type of school: [ ] Public [ ] Private [ ] Parochial
- Setting of school: [ ] Rural [ ] Suburban [ ] Urban [ ] Mix
- Location of school:
  - City: [ ]
- State: [ ]
- Country: [ ]

At your school, must students pass high stakes tests in order to graduate? [ ] Yes [ ] No

If yes, have these tests affected the course content in first-year chemistry?

- Not at all [ ]
- A few changes [ ]
- A large number of changes [ ]
- Changed the course completely [ ]

Directions: Below are a number of topics commonly addressed in first-year high school chemistry courses. Please mark the appropriate column(s) for each subtopic. Once you have completed the survey, you will have the opportunity to make additional comments. Thank you very much for your input!

<table>
<thead>
<tr>
<th>Structure of matter</th>
<th>Covered when I started teaching chemistry</th>
<th>Cover in my current chemistry teaching</th>
<th>Never covered in my chemistry teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>01. Evidence for the atomic theory</td>
<td>[ ]</td>
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</tr>
<tr>
<td>02. Atomic masses</td>
<td>[ ]</td>
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<tr>
<td>03. Atomic number and mass number; isotopes</td>
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<td>[ ]</td>
<td>[ ]</td>
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<tr>
<td>04. Electron energy levels; atomic spectra, atomic orbitals</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>05. Periodic relationships including atomic radii, ionization energies, electron affinities, oxidation states</td>
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<td>[ ]</td>
</tr>
<tr>
<td>06. Chemical bonding - Bonding forces types: ionic, covalent, metallic, hydrogen bonding, van der Waals (including London dispersion force)</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>07. Relationships of binding forces to states, structures, and properties of matter</td>
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<td>[ ]</td>
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<tr>
<td>08. Polarity of bonds, electronegativities</td>
<td>[ ]</td>
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</tr>
<tr>
<td>09. Molecular models - Lewis structures</td>
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<tr>
<td>10. VSEPR</td>
<td>[ ]</td>
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<tr>
<td>11. Geometry of molecules and ions, relation of properties to structure</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>12. Nuclear chemistry, nuclear equations, half-lives and radioactivity, chemical applications</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>States of Matter</td>
<td>Covered when I started teaching chemistry</td>
<td>Cover in my current chemistry teaching</td>
<td>Never covered in my chemistry teaching</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
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<tr>
<td>13. Laws of ideal gases</td>
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<tr>
<td>14. Equation of state for an ideal gas</td>
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<tr>
<td>15. Partial pressures</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>16. Kinetic-molecular theory: interpreting ideal gas laws on basis of this theory</td>
<td>☐</td>
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<tr>
<td>17. Avogadro's hypothesis and the mole concept</td>
<td>☐</td>
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</tr>
<tr>
<td>18. Dependence of kinetic energy of molecules on temperature</td>
<td>☐</td>
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<tr>
<td>19. Deviations from ideal gas laws (qualitative aspects)</td>
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<tr>
<td>20. Liquids and solids: from the kinetic-molecular viewpoint</td>
<td>☐</td>
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<tr>
<td>21. Changes of state, including critical points and triple points</td>
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<tr>
<td>22. Structures of solids</td>
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<tr>
<td>23. Solutions: Types of solutions and factors affecting solubility</td>
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<tr>
<td>24. Methods of expressing concentration</td>
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<tr>
<td>25. Colligative properties (nonvolatile solutes—qualitatively)</td>
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<tr>
<td>Reactions</td>
<td>Covered when I started teaching chemistry</td>
<td>Cover in my current chemistry teaching</td>
<td>Never covered in my chemistry teaching</td>
</tr>
<tr>
<td>26. Acid-based reactions; concepts of Arrheniun, Bronsted-Lowry</td>
<td>☐</td>
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<tr>
<td>27. Precipitation reactions</td>
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<tr>
<td>28. Oxidation-reduction reactions: oxidation number</td>
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<tr>
<td>29. The role of electrons in oxidation-reduction</td>
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</tr>
<tr>
<td>30. Electrochemistry: electrolytic and galvanic cells; standard half-cell potentials</td>
<td>☐</td>
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</tr>
<tr>
<td>31. Prediction of the direction of redox reactions</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>32. Stoichiometry: ionic and molecular species present in chemical systems; net ionic equations</td>
<td>☐</td>
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</tr>
<tr>
<td>33. Balancing reaction equations</td>
<td>☐</td>
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<tr>
<td>34. Balancing redox reaction equations</td>
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<tr>
<td>35. Mass and volume relations with emphasis on the mole concept</td>
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<tr>
<td>36. Empirical formulas</td>
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</tr>
<tr>
<td>37. Limiting reactants</td>
<td>☐</td>
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</table>
### Reactions (continued)

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Covered when I started teaching chemistry</th>
<th>Cover in my current chemistry teaching</th>
<th>Never covered in my chemistry teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>38. Equilibrium; Concept of dynamic equilibrium; physical and chemical; Le Châtelier's principle</td>
<td>○</td>
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</tr>
<tr>
<td>39. Setting up equilibrium constant for gaseous reactions</td>
<td>○</td>
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<tr>
<td>40. Setting up equilibrium constant for reactions in solution</td>
<td>○</td>
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<tr>
<td>41. Common ion effect, definition of a buffer solution</td>
<td>○</td>
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<tr>
<td>42. Kinetics; Concept of rate of reaction</td>
<td>○</td>
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<tr>
<td>43. Effect of temperature change on rates</td>
<td>○</td>
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<tr>
<td>44. Energy of activation; the role of catalysts</td>
<td>○</td>
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<tr>
<td>45. Thermodynamics; State functions</td>
<td>○</td>
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</tr>
<tr>
<td>46. First law; change in enthalpy</td>
<td>○</td>
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<td>○</td>
</tr>
<tr>
<td>47. Heat of formation and heat of reaction</td>
<td>○</td>
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<tr>
<td>48. Hess's law</td>
<td>○</td>
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<tr>
<td>49. Heats of vaporization and fusion</td>
<td>○</td>
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<tr>
<td>50. Calorimetry</td>
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</tbody>
</table>

### Descriptive Chemistry

<table>
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<tr>
<th>Topic</th>
<th>Covered when I started teaching chemistry</th>
<th>Cover in my current chemistry teaching</th>
<th>Never covered in my chemistry teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>51. Chemical reactivity</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>52. Products of chemical reactions</td>
<td>○</td>
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</tr>
<tr>
<td>53. Relationships in the periodic table; Horizontal, vertical and diagonal with examples</td>
<td>○</td>
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<tr>
<td>54. Alkali metals, alkaline earth metals, halogens, and the first series of transition elements</td>
<td>○</td>
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</tbody>
</table>

### Laboratory

<table>
<thead>
<tr>
<th>Topic</th>
<th>Covered when I started teaching chemistry</th>
<th>Cover in my current chemistry teaching</th>
<th>Never covered in my chemistry teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>55. Making observations of chemical reactions and substances</td>
<td>○</td>
<td>○</td>
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<tr>
<td>56. Recording data</td>
<td>○</td>
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<tr>
<td>57. Interpreting results based on the data obtained</td>
<td>○</td>
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</tr>
<tr>
<td>58. Communicating effectively the results of experimental work</td>
<td>○</td>
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</table>

### (Optional) Open-ended questions:

58. In your opinion, what has been the greatest change in high school chemistry instruction in the past 30 years?

- 

### Other comments about this survey:

- 

---

Thank you for your participation in our survey!
<table>
<thead>
<tr>
<th>ITEM</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Logically organized table of contents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Glossary that defines technical terms in understandable language</td>
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<tr>
<td>3. Index integrates concepts dispersed throughout the text</td>
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<tr>
<td>4. Overviews or graphic devices throughout the text that emphasize what the reader should learn in the chapters or sections</td>
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<tr>
<td>5. Marginal annotations or footnotes that instruct the reader</td>
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<tr>
<td>6. Chapter summaries that reflect its main points</td>
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<tr>
<td>7. Problems or questions at the literal level at the end of each chapter</td>
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<td>8. Problems or questions at the interpretive level at the end of each chapter</td>
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<tr>
<td>9. Problems or questions at the applied level at the end of each chapter</td>
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<tr>
<td>10. Problems or questions at the evaluative level at the end of each chapter</td>
<td></td>
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</tr>
<tr>
<td>11. Information provided in the text that enables the reader to apply the knowledge in the text to new situations</td>
<td></td>
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</tr>
</tbody>
</table>

**Totals**

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Page #</th>
<th># Sentences</th>
<th># Syllables</th>
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<tr>
<td>AVERAGE</td>
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**Level from Fry graph =** __________
<table>
<thead>
<tr>
<th>CRITERION</th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
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<tbody>
<tr>
<td>1. The introduction to the book and each chapter explain their purposes.</td>
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<td>2. The introduction provides information on the sequence of the text's contents.</td>
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<td>3. The introduction communicates how the reader should learn from the text.</td>
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<td>4. The ideas presented in the text follow a unidirectional sequence.</td>
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<td>5. The type of paragraph structure organizes information to facilitate memory.</td>
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<tr>
<td>6. Ideas are hierarchically structured either verbally or graphically.</td>
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<td>7. The author provides cues to the way information will be presented.</td>
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<td>8. Signal words and rhetorical devices interrelate sentences, paragraphs, and larger units of discourse.</td>
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<td>9. The style of writing is consistent and coherent.</td>
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<td>10. The text is cohesive.</td>
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<td>11. The text orients students to a level that is appropriate for the student.</td>
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<td>12. The text provides reasons for functions or events.</td>
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<td>13. The text highlights or italicizes and defines new terms as they are introduced at a level that is familiar to the student.</td>
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<td>14. The text provides necessary background knowledge.</td>
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<td>15. The author uses examples, analogies, etc., that clarify new ideas and makes them vivid.</td>
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<td>16. The author explains ideas in relatively short sentences.</td>
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<td>17. The author explicates theory on which the text is based.</td>
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<td>18. The author introduces, defines or clarifies, and integrates ideas with semantically related ideas previously presented in the text.</td>
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<td>19. The vocabulary load is appropriate.</td>
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<td>20. The text uses active sentences.</td>
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<td>21. Sentences are short, but still communicate effectively.</td>
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<td>22. Paragraphs vary in length ranging from one sentence to about a third to a half a page.</td>
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<td>23. The author uses personal pronouns and sentences that make the text more interesting to the reader.</td>
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<td>24. The text contains headings and subheadings that divide the text into categories that enable readers to perceive the major ideas.</td>
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<td>25. The text uses simpler, high-frequency words whenever it is appropriate to do so.</td>
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<td>26. Embedded sentences or phrases do not split kernel sentences (subject-verb-object).</td>
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<td>27. Referents for pronouns or other anaphora are not ambiguous.</td>
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<td>28. Punctuation helps make the text clear, but does not overburden the reader.</td>
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<td>29. New concepts are introduced with adequate examples, properties, and relationships to associated concepts.</td>
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<td>30. Generalizations are adequately developed.</td>
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<td>31. Information and ideas are communicated objectively with appropriate qualifications or alternate views whenever necessary.</td>
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<td>32. Features in the text make it appealing to students.</td>
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**GRAND TOTAL TEXT FRIENDLINESS =**
<table>
<thead>
<tr>
<th>Topic</th>
<th>Text</th>
<th># pages</th>
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<tr>
<td># photos b &amp; w color</td>
<td>ethnic and/or gender diversity</td>
<td>career</td>
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<td># diagrams b &amp; w color</td>
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Use of symbolic chemistry

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<tr>
<th># worked example questions and problems</th>
<th>qualitative</th>
<th>quantitative</th>
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</thead>
<tbody>
<tr>
<td># practice questions and problems</td>
<td>qualitative</td>
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Supporting information in appendices

<table>
<thead>
<tr>
<th>Topic</th>
<th>Text</th>
<th># pages</th>
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<td># diagrams b &amp; w color</td>
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Use of symbolic chemistry

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<tr>
<th># worked example questions and problems</th>
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<tbody>
<tr>
<td># practice questions and problems</td>
<td>qualitative</td>
<td>quantitative</td>
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</tbody>
</table>

Supporting information in appendices
Textbook Use Survey—Initial Survey

Name: ______________________________

Initial Review of Textbook Use
Chemistry 1073, Spring 2000

Please, take time to review your textbook and then rate the following qualities as you see fit.

<table>
<thead>
<tr>
<th>Quality/Usefulness of Text</th>
<th>Rating</th>
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<tbody>
<tr>
<td></td>
<td>Definite</td>
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<tr>
<td>1. Does the text have a clear sense of purpose?</td>
<td>1</td>
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<tr>
<td>2. Will the text assist you in learning chemistry?</td>
<td>1</td>
</tr>
<tr>
<td>3. Is the reading level appropriate?</td>
<td>1</td>
</tr>
<tr>
<td>4. Are you alerted to important information?</td>
<td>1</td>
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<td>5. Will the text hold your interest?</td>
<td>1</td>
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<tr>
<td>6. Are major points developed meaningfully?</td>
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<td>7. Is an opportunity for practice provided?</td>
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<td>8. Does the text encourage independent thinking?</td>
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<tr>
<td>9. Will the text help guide your study?</td>
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<tr>
<td>10. Is this text similar to previous ones you've read?</td>
<td>1</td>
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</tbody>
</table>

Prior use of HIGH SCHOOL chemistry textbooks:
(If you did not take high school chemistry, leave this section blank)

Name and/or author of your textbook (if you recall):

1. How often did you read the textbook? ______ per week
2. How many hours did you spend reading the textbook? ______ per week
3. You most frequently accessed the textbook: (choose one)
   a. On a daily basis
   b. Before homework/problem sets were due
   c. Night before an exam
   d. Never
4. The teacher closely followed the outline of the textbook. Yes No (circle one)
5. You were requested to make use of your textbook in the following ways. (Rate 1-8, 8 being the most frequently used example.)
   a. For vocabulary clarification
   b. To supplement class lecture notes
   c. Main source of information for course
   d. Initial information prior to lecture (including skimming, outlining, etc.)
   e. To get ideas of the applications of chemistry
   f. To look up physical constants or other chemical data (like atomic weights, etc.)
   g. For clarification of content presented in lecture
   h. To complete homework assignments
6. Did your course have a laboratory manual associated with it? Yes No (circle)
7. How often did you attend lab on the average? ______ per week

Prior use of COLLEGE chemistry textbooks:
(If you have never taken a college-level chemistry course, leave this section blank)

1. How often did you read or refer to the textbook? ______ per week
2. How many hours did you spend reading the textbook? ______ per week
3. You most frequently accessed the textbook: (choose one)
   a. On a daily basis
   b. Before homework/problem sets were due
   c. Night before an exam
   d. Never
4. Your favorite area of chemistry is ________________________________
5. Your least favorite area of chemistry is ________________________________
6. If you remember, who was the author of the textbook? ______________________________________
Demographic Data
CHE 1073, Spring 2000

Gender (circle one):  M  F

Year graduated from high school:  

Ethnicity:  

Entrance exam scores:
- TAAS (exit level)  Math  English  
- TASP-Math  English  Exempt:  Y  N (circle)
- SAT-Math  SAT-Verbal  SAT-Total  
- ACT-Composite  

Number of years of high school chemistry  What was the last year?  

Number of years of high school mathematics  What was the last year?  
Which of the following did you successfully complete? (check all that apply)
- Algebra I  
- Geometry  
- Algebra II  
- Pre-calculus (or Analysis)  
- Calculus  
- Other (higher than calculus)  Specify:  

List prior college-level chemistry courses and institution where taken.

List your highest level of college mathematics successfully completed and where taken.

For your degree, what courses in chemistry are required?
- Basic Chemistry  
- General Chemistry (Chem I)  
- Chemical Principles (Chem II)  
- Organic Chemistry I  
- Organic Chemistry II  
- Physical Chemistry I  
- Physical Chemistry II  
- Analytical Chemistry  
- Advanced Inorganic Chemistry  

You are currently seeking a degree in  

80
Textbook Use Survey—Weekly Survey

Name: __________________________

Weekly Survey of Textbook and Lecture Notes Use  
Spring 2000, Chemistry 1073  
(due every Tuesday of the semester)

1. I spent ________ hours this week using Zumdahl.

2. The most frequent time I accessed the book was:
   ___________________ day of the week between _________ and _________ times

3. I found it necessary to consult another textbook. Yes or No (circle)
   If "yes", who was the author? __________________________

4. After every lecture, I supplemented my class lecture notes with information from the Zumdahl textbook. Yes or No (circle)
   In order to complete the problem sets;
   4. I only used the textbook (never my lecture notes). Yes or No (circle)
   5. I used both my lecture notes and the textbook. Yes or No (circle)
   6. I never referred to the textbook (except to get the questions!). Yes or No (circle)

7. Please rate 1 to 10 (no fractions!), the usefulness of your textbook this week. _____

8. Please rate 1 to 10 (no fractions!), the usefulness of your lecture notes this week. _____

9. Please rate 1 to 10 (no fractions!), the helpfulness of your pTA this week. _____

10. How many hours did you meet with your pTA this week? _____

Comments: (optional)
Textbook Use Survey—Final Survey Form

Final Review of Textbook Use
Chemistry 1073, Spring 2000

Please rate the following qualities regarding the Zumdahl textbook.

Quality/Usefulness of Text

<table>
<thead>
<tr>
<th>Rating</th>
<th>Definite</th>
<th>Yes</th>
<th>Neutral</th>
<th>No</th>
<th>Definite</th>
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1. Did the text have a clear sense of purpose?
2. Did the text assist you in learning chemistry?
3. Was the reading level appropriate?
4. Did the text alert you to important information?
5. Did the text hold your interest?
6. Were major points developed meaningfully?
7. Was an opportunity for practice provided?
8. Did the text encourage independent thinking?
9. Did the text help guide your study?
10. Was this text similar to previous ones you've read?

Other

11. Vocabulary recognition is important to learning chemistry? 1 2 3 4 5
12. Prior mathematics knowledge is important to learning chem? 1 2 3 4 5
13. Prior chemistry knowledge is important to learning chem? 1 2 3 4 5

Rate the following (1-10) as to what was the most helpful part of this course; use 1 for the most helpful, 10 for the least. Use each number only once.

---
Your prior mathematics knowledge
Your prior chemistry knowledge
Your logical thinking skills
Your ability to solve problems
Class lectures
pTA sessions
Outside tutoring (not including on-campus tutoring)
Problem sets (homework)
Use of textbook (either Zumdahl or other)
Your motivation
---

On the average how many hours per week did you use the textbook? ________
You referred to the textbook (daily, every other day, weekly, biweekly, monthly, never). Circle one!
Your instructor closely followed the textbook in this course. Yes or No Circle one!
Your favorite area of chemistry is ____________________________
Your least favorite area of chemistry is ____________________________
You are currently seeking a degree in ____________________________
If you attended the pTA sessions, who was your pTA? ____________________________
Rate your pTA, 1=10, with 10 being the best. ________
You would like to be a pTA next fall. Yes No Circle one!
APPENDIX C

SURVEY COMMENTS AND INTERVIEW TRANSCRIPTS
Survey Comments from United States Teachers—Page 1 of 5

0-5 years experience:

1) Only cover material covered by state test, but we do go slightly beyond that for the advanced classes.

2) Constructivism

3) Online simulations. PHGT University of Colorado (macro level views) sensor availability (Vernier, Pasco) supporting independand study in the high school.

4) Much less time to cover topics, less depth, more memorization and less analysis. My county severely restricts chemical use which limits us to household and benign chemicals, and restricts the number of labs we can do well.

5) Lack of motivation of students, apathetic.

6) Computer textbooks, blackboard, interactive chem.

7) More content and rigor and lab skills have been added to what was a very watered down curriculum.

8) Because I am a new teacher, I answered the questions based on what is in the curriculum for this coming year.

9) Being a new teacher the biggest changes I notice are in the teaching of concepts in depth. Most topics are still covered, but only at a surface level. The Virginia SOL tests are a disgrace!

6-19 years experience:

1) I don't know, I haven't been teaching that long.

2) Inquiry & the push for students to create models and destroy their misconceptions.

3) Retention and transfer of learning
4) More expectations from the state.
5) Ability to solve problems that are different from what they were specifically taught.
6) More emphasis on chemical bonding, I did not cover organic chemistry at the start of my career, but now I do.
7) The decay in general math understanding by the inclusion of the calculator, too early in school.
8) Depth & range of topics along with requirement. Everyone to pass chemistry or physics beginning this year.
9) Having to teach to a test and loss of class time.
10) Math ability has decreased.
11) Content is now broader and includes more emphasis on electron structure, many more hands on activities are done, but less "wet labs."
12) Watered down curriculum
13) Diminution of hands on demos & labs in favor of pictures/power points/videos.
14) Need to teach math skills and problem solving is increasing.
15) Students no longer have the math skills needed to succeed in chemistry. The students are dependent on the calculator and cannot estimate or realize if their answers are reasonable.
16) Watering down the math and reduction in labs completed.
17) Inquiry both in content and in lab.
18) Today's students can't sit and learn from lecture, not socialized to do so.
19) State tests I must be done teaching content by beginning of May. Consequently, I cover little on acid/base, equilibrium, kinetics. I cover no nuclear or electrochem. Difficult to motivate students after state test. I fill that time w/labs.

20) More inquiry & less lecture.

21) The shift from the teacher centered classroom to a student centered classroom, from didactic to inquiry. Technology!

22) It is less rote; less memorization.

23) Emphasis is more on qualitative concepts and not the quantitative aspects of chemistry. More people who do not have a strong background in chemistry are teaching it today.

24) Decrease in number of labs. Less critical thinking.

25) Although I have not taught chemistry for a large number of years, the years have been widely separated. I first taught chemistry in 1977 - 1980 and returned to school in 2000.

26) My school doesn't adhere to state standards, so we haven't been substantially affected by changes in them.

27) The VA Chem SOL tests began my first year of teaching, so I don't know how much change the standards caused on first year chemistry.

20 or more years of experience:

1) When I started, there were no real rules or guidelines. Now there are way too many. If I taught for another thirty years, maybe the happy middle ground could be found. At
this point everything from the “allowed” chemicals and “required” labs, tests, grading, and tech is interfering with learning.

2) The guided inquiry/inquiry trend.

3) Micro labs, lot of labs have been removed due to dangerous reactions /reagents

4) When I first started teaching I did not cover as much information but what I did cover, I did in depth. Now I feel that I cover a lot but they don't know it as well.

5) Lecture gone. Inquiry focus now. Less time in class now...trimesters (yuk!)

6) Inclusion of nearly all students in chemistry classes.

7) The students only want to learn what is needed for the test. They have difficulty retaining information for any extended period of time.

8) Computers, animations, virtual labs, etc., in the classroom. Making up tests, power pts, websites.

9) Technology, scope

10) Covers a lot less material in less depth.

11) The addition of more descriptive, hands on lab oriented chemistry instruction (more inquiry based).

12) De-emphasis on lab experience due to cost and safety (tort) issues.

13) Use of technology.

14) Why and how have changed more than what is taught much much more rote memorization. Less thinking and doing.

15) Time limitations have decreased what I can teach.
16) 2 changes—far more inquiry in lab, but less descriptive chemistry. Far more cooperative learning, especially in problem solving as well as labs. I also notice topics, while still covered, are in less depth than before, to make time for inquiry, review for state tests.
Survey Comments from Texas Teachers—Page 1 of 2

0-5 years experience:

1) Making it a graduation requirement.

2) Providing a true relationship between the classroom and life.

3) More concentration on lab activities

4) The rigor. I remember when the topics were more rigorous. Students were expected to do homework to keep up

6-19 years experience:

1) Students came in knowing less. We have to teach metric/SI, dimensional analysis, periodic table, etc. This used to be covered/expected knowledge of students coming into chemistry so chemistry could start with naming compounds/writing formulas.

2) Aiming at TAKS/TEKS objectives instead of chemistry content.

3) Less laboratory reactions and a greater number of preset/packed labs with little room for variability. It appears to be a safety issue, rather than actually teaching safety.

4) More thermochemistry.

5) More emphasis on calculations

6) Moving away from some basic principles, use gas laws, kinetics, thermochemistry.

7) Not enough time.

8) Emphasis has moved toward passing TAKS test. I'll be glad to go back to studying chemistry for chemistry's sake!

9) Student motivation

10) It's watered down.

11) Keep the math in!
12) Technology available.

13) More concentration on lab activities.

14) The rigor. I remember when the topics were more rigorous. Students were expected to do homework to keep up. Does your question only cover old TEKS?

20 or more years experience:

1) From rigorous lab triggered concept development to visual oriented descriptive chemistry.

2) I take five weeks to teach biology and physics and review chem, but mostly other two above, in order to prepare for TAKS test.

3) Lack of classtime "thirty hours different"

4) Commitment level of students to learn.

5) TAKS, inclusion of all students.

6) Greatest change is the students background & the depth to which students understand. I find their ability to relate ideas and retain info severely reduced (one year to teach them chem forty five years ago).

7) More emphasis on calculations

8) Students not successful in chem must stay in chem and pass.

9) Moving away from the mole due to TEKS and now going back to it due to state EOC tests.

10) Student attitude, just give me the grade. I don't need to know this once I get out of class.
0-5 years experience

age 33, my second year with chemistry students, male, public school, urban, yes

on testing, it’s changed the course completely

1) change in instruction: What I—I—I spent the last two summers going through the UT Dana Center at Fort Worth’s Museum of Science and History—their inquiry program. And so more and more of my labs are becoming student-centered, guided inquiry. So that’s something that’s continuing to evolve in my classroom. And it’s kinda hard to find . . . just the right chemistry lab to tweak, to turn it over. So that’s one big change in my classroom, in my teaching.

2) why: The kids….this is…this was just reinforced when we looked up the analysis of our first six weeks of data. If the kids don’t do it—put their hands in it—they don’t learn it, they don’t remember it. And it shows up on all the high-stakes testing.

3) achievement: I think they’re probably doing more work, in my classroom, but they’re not realizing they’re doing more work. Because it is more student centered there’s some liberty in there—kinda take ownership—they’re willing to do that work. Their grades—really haven’t changed.

4 & 5) what and how you teach: I sneak in what I think is important—that is not high stakes tested—when I can. And when I know I won’t get caught doing it. But otherwise, if it’s not a testable objective, they wanna know why am I doing it in my classroom?

6) student understood: naming compounds—I just don’t remember the student or the conversation. I just remember seeing the light bulb go off over a kid’s head—“this is
so easy!" Because he saw the trend—he finally found—he finally saw all the trends and how all the rules fit together. And he was like “that’s all there is to it?”

age 33, 2 years experience, female, public, urban, yes to testing, changed a large number of changes.

1) change in instruction: they say that we don’t teach to the test, but I’ve found myself more and more trying to cater towards TAKS, especially with the kids that don’t come in with the background they need, especially in math, so we have to review the basics before we can actually teach school.

2) why: Students changed, their needs are changing.

3) achievement: It’s different, achievement from their control and so forth, they’ve got that sense of pride, they’ve got something that stayed here (motioned to head), you know, even though their test grade says it’s not there, they know it, they just don’t know it the way we need them to.

4 & 5) what and how you teach: I consider myself to be a chemistry teacher, and that’s what my title says, but I find that most of the year I end up teaching biology and teaching physics, because we have to review for the exit level, so we have to review chemistry. We have to leave out some of the material in chemistry in order to get to all the TEKS for TAKS.

6) student understood: I had a guy, who sat in the back of my class, he’s ah, he plays stupid. A gangbanger, you know, he likes to be thought of as cool rather than smart. So I was explaining something, I can’t even remember what the concept was, to the students, and one of my students tried to give me an example: “Oh, is it like…….”
and it was random, I don’t even remember. Usually with him, in the back with his pants sagging, his head down, looked up and said, “No, stupid, it’s….” and he explained it and gave a better example than I ever could. Hey, you exist! And it actually was a very good example. And I thought he was sitting in the back not listening, just sleeping. I thought, “let’s not call her stupid, but that’s a really good example.”

7) anything else to add: Down with TAKS! (laughter)

---

age 30, yrs 3, male, public, suburban/rural, tests yes, definitely have affected chemistry course, a large number of changes, I’d almost say changed it completely.

1) change in instruction: So, specifically, last year, my instruction was going along, and then about the second or third week of the second semester, they decided to, uh, I guess, start reviewing for TAKS. And so my students are sophomores, and they were biology students before that, and so they had no introduction to any IPC physics or anything like that. So we stopped the curriculum teaching, and for three weeks straight, we taught physics, Newtonian physics. So, all that stuff, and consequently, you know, we didn’t get an opportunity to finish or go as far in depth as we needed to, a lot of the other chemistry topics, electrochemistry, thermodynamics, even just like simple stuff, like lots of stoichiometric calculations and things like that, just completely skipped over, ‘cause there was, “Oh, this isn’t TAKS tested, so we’re not going to worry about that.”

2) why: because of TAKS

3) student achievement: I’m not sure I have the data to completely answer that question. (any drastic changes?) I’m certain that it has, like I said, I just haven’t had the
opportunity to spend as much time on topics the students struggle with, we’re always under pressure to make sure the students pass the standardized test. So, I’m certain that students don’t have the complete grasp of what they need to have in order to be able say that they understand a topic completely. I had that constantly-rushed feeling—“Ok, we’re starting this content area now, and we going to be done in two days, three days”—that’s it. (Have their grades stayed the same?) No, I wouldn’t necessarily say so—I’ve noticed…..I guess they pretty much have stayed the same, but it’s such a low level of performance—it’s not like they dropped, they were already performing poorly. There wasn’t much more room for them to go down.

4 & 5) what and how you teach: There’s a lot more emphasis on, uh, TEKS identification, TEKS vocabulary, look at this, you know, what is this verb asking, come up with specifics that are directly related to all those TEKS that are tested, objectives. So a lot of the time it’s very specific about, instead of being inquiry-based, it’s like, “OK, here’s this objective, here’s what you’re going to learn, this is how you’re going to learn it,” and there’s not really an opportunity to do, like, for discovery or an inquiry-type thing. It’s just so much of the actual TAKS test, there’s like a third of it that’s specifically along the lines of, you investigate the (unintelligible), and the kids haven’t got the experience of investigating everything because it’s just being handed to them.

6) student understood: So, I have a thing at the beginning of my class, like a bell-ringer or a warm-up activity that we do. So I’ve been trying to get into the habit where I’m really trying to reinforce the behavior, doing that whole thing and everything. So as soon as the bell rings I’m like, “Alright, guys, let’s check to see that you’re working on
your warm-up,” and I give the kids a stamp on their paper and they just love it—they go nuts to get their stamps. I’ve noticed a couple of students who are getting to the point where, now, they understand the concept to do whatever it is we’re doing, well enough to explain it to their friends, how to do what they’re doing, because their friend across the room will be like, “Hey, I don’t know what I’m doing.” This person will actually get up and go over there and squat right next to the desk just like I do, and be like, “So this where you gotta to find this information in the periodic table, and all of these have the same number in the column as this one.” And I’m like, “She knows it! And she’s right! And she showed him perfectly, step by step, exactly how to do it.” And I’m like, “Ahhhhhh! She didn’t know it before, but she knows it now.”

age 50, 3 years exp., female, public, suburban, yes to tests, a moderate number of changes

1 & 2) change in instruction and why: We aren’t spending as much time on nuclear chemistry, our new curriculum has us teaching thermal chemistry, which we’ve never done before. So, after the TAKS test in May, we’ll be teaching enthalpy, entropy, delta h, delta s, so that’s a major change. The district waited until the new TEKS were out, and they rewrote the district curriculum to reflect that. So this will be the first year we teach this new curriculum. And we teach regular chemistry, so we have some students who aren’t as proficient in math and so any time we’re dong math stuff in chemistry it’s a struggle.
3) student achievement: it’s not going to affect student achievement in chemistry, hardly.

4 & 5) what and how you teach: The EOCS are gonna be better because we won’t have to teach biology and physics, because right now when they take the TAKS it has all three subjects on it. And so two weeks before TAKS, we’re like cramming bio, since they had it in ninth grade, and cramming physics because they haven’t had it yet. And so now with the EOC, at least we’ll just be responsible for our curriculum in chemistry. We won’t have to spend two weeks on bio and physics.(time in lab? Projects? Activities?): It should get better with EOCS, because we don’t have to do TAKS blitz.

6) student understood: On 10/23 we had Mole Day, and so we went outside and had a carnival with different stations, and there was one with “drink a mole of lemonade. “ So they had to mass their cup with the lemonade, drink their lemonade, mass their empty cup, and then I had a dry erase board where they had to calculate the moles of lemonade that they drank. And we just assumed it was water, so we used the molar mass of 18 grams per mole, and so—do you know that almost every kid did that station because they wanted the lemonade?—and so that showed me that they knew how to do that conversion.

age 57, 5 yrs exp., female, public, suburban, yes to tests, a few changes

1) change in instruction: I am concerned because it is too much math work, it’s only math, math, math, and it’s a dry topic.
2) why: too much math in chemistry

3) student achievement: I guess it’s the same.

4 & 5) what and how you teach: With the new TEKS I would not say that it has changed how I teach, but I would get more time to do what I’m doing.

6) student understood: We did an activity. I did a mole lab using aluminum foil and asked them, make something nice with the aluminum foil, any article they would like, and when they made it, they said, “oh, I made this nice thing, and the amount of aluminum I used was not even half a mole.” So they got it. We called it “foil-a-gami.” And one of my students made such a nice falcon, the mascot of the school. I hung it from the ceiling, it was so nice. But it was fragile, so I put it where no one could reach it.

6-19 years experience

age 50, years teaching chemistry 17, female, public, suburban--test? Yes-a large number of changes

1) change in instruction: We have to do TAKS folders every day the first ten minutes of class. We’re on an A-B block, 90 min each, and they have to answer three released TAKS questions a day and they have to put their confidence level from one to five, how they felt about the question.

(This is rather elaborate!) Yes, the folders have to be available for any administrator to come in at any time and look at a student. (Do they do that?) Not yet. They’ve added another benchmark, so we do two benchmarks the first semester—well, one the first semester and one the second with a checkpoint every six weeks and the
warm-ups every day. And then four weeks of TAKS rotations—three weeks of rotations and one week of tests.

2) why: Pressure from the administration

3) student achievement: I think the grades have not been affected so much because we have lowered the curriculum standards so that--there’s the pressure of not having the failing rate greater than 20 percent.

4 & 5) what and how you teach: Yes, completely.

6) student understanding: I had several in pre-AP where the light bulb went on about quantum numbers, and it was almost like a domino effect. It happened to one, and then another and another, and then most of the class… (What did they do? What did they say?) They were excited. There was this expectation in their voices, they were happy about it, very pleased, and said they got it!

age 55, female, 17 years experience, public, suburban, yes on testing, my chemistry class has changed considerably because of this test. I feel that I’m not teaching chemistry anymore, I’m teaching IPC chemistry for a whole year instead of chemistry. Several of the more in depth concepts, I just end up having to skip over because we didn’t have time. I end up emphasizing the high stakes testing TEKS.

1 & 2) change in instruction and why: Well, I do not go very much in depth into s p d f electron orbitals, I don’t talk about Hund’s Rule, you know, um, so some of the fun things I used to do with that are gone. I’m not doing much with nuclear chemistry anymore. The gas laws, I now put at the end of school, after the TAKS test instead of
doing those a little earlier—because they're not tested on the TAKS test, and we have to cover everything that is tested on the TAKS test. We have to finish up about 3 weeks before the tests begin, because we stop everything and have a three-week review, where the kids go and do a hands-on lab setup every day for three weeks. So that's a huge change. We basically have to be finished with our chemistry curriculum in the first three nine weeks, except for finishing up gas laws at the end where we can actually have some fun.

3) achievement: I have lower-level kids now, and I don't know if it's affected their grades that much. They don't achieve very much, it seems to me. They want everything given to them, they want completion grades if they just write down, y'know, their name on the paper basically. I don't know if it's because of emphasis on TAKS, but it seems to me that we're shooting at mediocrity in our school, because we're aiming at the kids who either just barely pass the TAKS or just barely miss passing the TAKS. So that's where our emphasis seems to be. (the bubble people?) Yes, that's exactly what they call them. “You need to know these bubble kids, you've got to live with these bubble kids.” No, thank you--I'm not living with my bubble kids.

4 & 5) what and how you teach: We have to finish up about 3 weeks before the tests begin, because we stop everything and have a three-week review, where the kids go and do a hands-on lab setup every day for three weeks. So that's a huge change. We basically have to be finished with our chemistry curriculum in the first three nine weeks, except for finishing up gas laws at the end where we can actually have some fun.
6) student understood: I'm not sure I can come up with one. One interaction, not so much with me, but I was observing one kid who understood how to get number of neutrons from atomic mass and atomic number, because they were explaining it to another student who was clueless. They understood enough to tell them how to do it. I was listening to be sure they were doing it correctly, and they were.

age 35, 11 years experience, female, public, urban, yes to testing, changed content completely,

1) change in instruction: a ton more repetition, a ton more visuals, less regular material, more of us trying to relate to the students and then bringing in my own stuff.

2) why: Students changed.

3) achievement: I find that …to me it seemed to help their grades, their interaction in class was great, they love coming to class now, they enjoy it, they listen. But I learned something (unintelligible). So, at least they’re happy, they’re not mad about coming to school.

4 & 5) what and how you teach: That’s exactly right—we’ve had to leave out topics in chemistry—we just hate to, but we can’t go more into debt. When you get them on something, and you just want to go with it, and you can’t…then you have to go back and go over…we have to be done by this time, so we go back three times.

6) student understood: Actually, after a test, we had some students come in in the morning, to go over the questions they missed, and it was over chemical changes versus properties, and so we talked about if it’s gonna be a change, then think of
(unintelligible), if it's going to be an action, if it's describing it or changing it. We started going through it, and one of the girls, “Oh, I get it,” and she’s going through every single question and looking at the words, lining up the verb and what happened. And then, so, she's able to say, “This is a property, no, this is a change,” and then well what kind of change. So that was their light bulb moment, and that made me feel good.

age 57, 14 yrs. Exp., public, suburban/ mix, yes on tests, content: changed it a little.

1) change in instruction: sequencing of topics. As in, you know how we used to do electron configuration, diagonal rule, and all that other, the Aufbau chant. Now I’m doing reading periodic table for configuration at the same time—I put ‘em together.

2) why: We changed curriculum last year, and the curriculum had it in that order. I didn't like it, the principal said you have to do it in this order, I did it, it seemed to work better—I hate that! (laughter) So I tried it again this year.

3) student achievement: I think they got a better understanding of it. But there was an extenuating circumstance. Our school flooded, and we were closed 4 days in the middle of that, so it’s hard to tell.

4) what you teach: I think I’m still doing it the same way, even though we’ve got standardized testing.

5) how you teach: I do know the topics that are going to be on the standardized test. So I probably do spend more time or stress those. I don’t know that it’s changed
how I present it or what I have the kids do, but... Stoichiometry's not on the standardized test, but it probably will be on the EOC.

6) student understood: Well, I guess when one of the students, when the rest of the class seemed to be confused, one of the students stood up and said, "This is the way ya do it," and pointed to the periodic table and taught it again! (did it work?) Yep! So, something about a kid telling another kid the exact same thing that I've just said.... Chemistry just hasn't been as exciting this year..... But I did have a few breakthroughs in physics that I didn't expect. The "village idiot" (laughter) got the bonus question, and it was one of those true bonus questions where you had to manipulate a formula with no numbers, and solve for like mu, without mass or force, all in variables. And I looked and said, "Whose paper is this?" and when I saw who it was, I looked to see if he had cheated off anyone else. And there was no one around him who got it! He must have figured it out! Chemistry is really, like, nondescript this year. I got a lot of special ed kids in there this year. We're talking about reading below grade level, math models, and.....

20 or more years experience

age 49, years teaching chem. 20, male, public, suburban, yes on tests, yes on
content

1) change in instruction: More last minute review prior to that end of course testing (Interesting. Have you built up to the end of course exams?) No, what I'm saying, even TAKS
2) why: TAKS

3) achievement: Overall chemistry achievement, it lowers it. But on the high stakes test, it increases it.

4 & 5) what and how you teach: No major changes—same old same old, ya know.

6) student understanding: Well, I, uh, I always like hearing a comment from a student that it related to something else, like they made it a connection to a prior, either prior knowledge, maybe even in physics or another class, or in IPC: “Oh, that’s why they taught this to us this way and now I understand it. And then I'll sorta have them—Well, what do you understand? Restate it back to me. Let me hear what you’re trying to describe, to see if you truly have an understanding of it. Because sometimes what they perceive to be an understanding is not in reality an understanding.

age 55, years teaching chemistry 32, female, public, suburban, yes on tests, changed content probably a little because I teach the pre-AP class, so I was able to sidestep...

1) change in instruction: Last year we just did the released TAKS and we probably spent less than five minutes on them. We also had to do the checkpoint testings, and the benchmark testings. The pre-AP kids didn’t have to do the TAKS rotations stuff. See that’s why I said that with pre-AP and AP, I was less affected. But the pre-AP kids do have to do the folders, too.
2) why: TAKS scores, accountability, the community wants to be exemplary, and they don’t understand that this test doesn’t tell them how educated their children are, and even if the district is unacceptable, it doesn’t mean that their child isn’t getting a good education, it means that one subpop area may be deficient (Or absent that day— does that still count?) Well, yes.

3) achievement: Everybody has to be able to do everything and everybody has to be the same. (Did their grades stay the same?) I would say pretty much the same.

4&5) what and how you teach: Yes, like I said before.

6) student understood: I’ve been doing some tutoring this past year, kind of the same thing, I had a student who was very panicked because of the electron test that was coming up, so we were going through it, and the comments were, “Well, now I understand it.” And what they don’t understand is that it was the second time they were hearing it, in a different situation, it’s a one out of thirty situation, and they ended up making a 93 on the test, so obviously they did get it! (laughter)

age: 55, yrs teaching 22, female, public, urban, yes on testing, moderate number of changes

1) change in instruction: I have to do biology TAKS warm-ups every day, to review biology TAKS content, so that they will pass that high stakes test at the end of the year. (Are you teaching physics, too?) The physics, they don’t struggle with as much, because it is so low level, and if you just remind them to flip the periodic table over and look at the formula chart, and use the formulas on the chart, they can answer
the physics questions. Statistically, we are not seeing tanking of the physics portion of the test like we are the biology portion of the test. Biology, we have to review every class period.

2) why: the test, of course.

3) student achievement: Most of my kids, I can whip them into line and they'll pass TAKS at the end of the year, because I talk TAKS every day, I put TAKS questions on every test. So, as far as chemistry achievement goes, I'm doing what I can. Their grades stay about the same. I don't think TAKS is impacting student grades, per se, in my class.

4 & 5) what and how you teach: Well, I don't know if it's the standardized testing that's changed it, but the district, the school district, is more and more focused on how we deliver content. So, AVID is the one program in Arlington, and I can't tell you what it stands for, but it's to help low achievers achieve. So they want us to be sure we use certain types of delivery, such as inquiry learning or more writing, more reading. And those kinds of things—and Cornell notes are very big on our campus. It's a very scripted way of taking notes and it's formatted, and at the end they have to write a conclusion about what they learned that day. I don't do it, but I get around that by telling them that chemistry has so many symbols in language so we have to deliver content in symbol language form. The students—I have a tremendous number of students with dyslexia or dysgraphia, which is a fine motor skill, and for them to have to write that and do it correctly, it's very hard, and so I don't have them take a lot of notes. We type them up ahead of time for them, to prevent mistakes. So they fill in the blanks, and the
Cornell notes format doesn't work as well in chemistry just because that information we require them to take down is so easily jumbled for those kids.

6) student understood: This one student is special ed but........she really understands. You know, dimensional analysis can be hard, but we're doing grams to moles and moles to grams, and she really just whips through it. No problem with it. Now, writing formulas from symbols, like getting the numbers right, that's where her disability shows up. If she has the formula correctly scribed out for her, then she can calculate molar mass, she can set the dimensional analysis up, no problem. But if she has to start from a word formula, then chances are she won't—she won't scribe it correctly—she won't get those subscripts correct. But if I give the correct formula to her, she can go right through it. It's wonderful for her—she has confidence because she is succeeding. She probably wouldn't be predicted to succeed in the class based on her modifications, but she seems to—she's a leader in the class because she has discovered a great work ethic, and that if she does try, she can do it. And that's a very hard thing to test—if they just don't want to try, and if they don't want to work any more. They're putting way too much responsibility on the teacher to get the kid to pass, and not enough on—there is no responsibility to the parents or the students. It's really all on the teacher, and that's impossible—it has to be all of us. The kids want to be little worms, little birds—they want us to just feed it to them and that doesn't work very well with chemistry. What I love about Lisa is, she will do the work for me, she will come in for ten minutes after school if she doesn't understand something and clear up any misconceptions. How hard it is to get a child to do that nowadays. Not just say it's too
hard from the get-go—and just throw their hands up. I mean, I have another student and he just wanted to quit—he just was giving up on some of this, and I just, I got in his face and said, “Quit that right now—you are a smart young man, so get after it! And I’m not accepting it, that you can’t do this—you can do it.” And now he’s got a good attitude—but I was really ugly to him. It’s a “by durning” in east Texas, but I’m gonna “by durn” ya. And all my students will tell you that I say “reading is” and they’ll go “fundamental”—that’s even for me. If I don’t read it, then I can’t understand it. Like putting the computer screen on the TV—I finally read the little message on the screen, and it said to change the pixelation—and then it shows up. I said, “See—I had to stop and read it. Just like I tell you. If you don’t read what it tells you, you can’t fix the problem.” Again, kids don’t wanna read—it’s a lost art.

age 46, 22 yrs exp., female, public, combination of rural and suburban, yes on tests, changes—a few changes.

1) change in instruction: I completely changed my AP curriculum. In first year—I went to notes. I was giving them notes instead of making them take notes. And I went from graded homework to graded daily quizzes.

2) why: Because our school district would no longer allow us to have graded homework. (the district wouldn’t?) No.

3) achievement: It’s gone up. (has it really?) It’s actually gone up. (are they happy with that?) Well, they’re happy with the achievement, but they hate the quizzes. The parents complain about so much homework—“Oh my child has all this
homework”—but not from me. But they do have daily quizzes. And their performance has gone up.

4) what you teach: We have added viscosity, and end of course will ensure that we teach every TEK, all the TEKS rather than skipping any.

5) how you teach: It hasn’t. Not at this point. At my other school, I had to teach TAKS all year. It was a low-performing campus.

6) student understood: I have tutorials every day, at lunch, and I have seen students that were making zeros on their quizzes and then all of a sudden they got the idea and they were making 100s, and helping other kids. And since they just made that change, I’ll listen to their explanation, and it’s twice as good as mine. And they actually enjoy teaching the students, the other students, rather than being the ones being taught. I’d say it was twice as good as I did, because they knew the kid. They gave these analogies that were so cool! The tutoring each other has really worked—I’ll have 25 or 30 kids and I’ll end up teaching maybe 5 of them, and I’ll have other students who say, “Hey, let me go teach them.” And I let them teach them. And I also started having them graph this year. I give them graphs and have them graph their quiz grades, and I didn’t give it on this unit, and they threw a fit. I asked them why do they want it—I don’t have time to make it right now, but why do you want it? And they said, “Because we’re climbing a hill to get to the top and stay there.”
age 47, 20 yr exp, female, public, rural, yes to testing, changes: not really. The only change I know of is that I have every kid taking chemistry now, whether they need to or not.

1) change in instruction: I sometimes don’t teach quite as high level as I used to. I keep the same concepts, but sometimes I kinda dumb it down, well, not dumb it down but drop the learning level just a little bit because they don’t get it. We’re doing theory, and it’s like, “Why do we have to do this?” whine, whine, whine.

2) why: Because my students aren’t mature enough. Emotionally. I teach ‘em all. Maturity-wise, they could just care less about learning anything about chemistry, “we’ll never use it again,” yadda, yadda, and “why am I having to sit through this?” is the response I usually get. And I can tell them that we use chemistry every day, we use it in cooking, we use it in this, we use it in that, and they still go, “so?” So it’s a maturity thing—juniors have always done a little better than I’m seeing with my sophomores. I think it’s also a brain thing—they do the math a lot better as juniors than they do as sophomores.

3) student achievement: They actually, when I’ve had students go to college, they come back and say, “Don’t change what you’re teaching, we use this in college.” Significant figures—I made them do significant figures, I stuck to my guns, they hated it, but I had a kid come back that didn’t have physics in high school and he’s taking college physics, and he’s going, “Thank you for making me learn how to do this, because I needed it and he didn’t explain it, he just said use it.” So, it was good. I get good feedback occasionally. It’s that one little glimmer of hope.
4) what you teach: It hasn’t. I haven’t really changed content. I’m not sure that I’ve changed anything that I’ve been teaching in chemistry, because I guess I teach it more like, “you’ll need this when you get to college,” and that’s been my philosophy for Lord knows how many years, and I’m trying to get to the point of they’re not all going to college, I need to change it a little bit here. But, the only thing I try to get to, and I’m really pushing it, is acids and bases, because I try to make sure they understand it instead of just “blblblbl” and we cover so many chapters in first semester that I go for a modest amount in spring. I don’t cover everything I’m supposed to. I have students that do exemplary on the TAKS test. I had two last year. One of them, you would never have thought it, because he’s taking chemistry again this year.

5) how you teach: I keep saying, “You’ll see this on the TAKS test,” “You need to know this because I’ve seen it on past TAKS tests.” It hasn’t affected how often we go to lab. I probably don’t do near as many labs as I should, because I don’t have all the stuff to do all the labs that I should. I still do the same labs I’ve always done. They’re good labs, they go with the topic, and I’m an old stick in the mud!

6) student understood: Colligative properties—the ice cream lab. Freezing point depression. Why do you put salt into it? So it will freeze. But it only gets down to zero, and that’s not cold enough to freeze it. And so I did this, and one time we had the bag that didn’t have a lot of salt in it, and we had it with the salt out the kazoo, you could tell the difference. Not a lot of salt didn’t freeze very well, and the other was as hard as a rock. I’ve had them fuss at each other over it: “No you’re not doing that right.” It
happens in class, too, if someone knows exactly what they're doing: "No, you don't do it that way, you do it this way."
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