

Chapter 1: Review of the Literature

1.1 History of the Web

The Soviet Union's launch of the first space satellite, Sputnik, was viewed by United States President Dwight D. Eisenhower as a military threat. To the United States, Sputnik demonstrated the advanced technological, scientific, and military capabilities of the Russians, all of which had the potential to threaten U.S. national security. In response to Sputnik, President Eisenhower created the Advanced Research Projects Agency (ARPA) in an attempt to "manage and direct selected basic and applied research and develop projects for the Department of Defense, and pursue research and technology where risk and payoff are both very high and where success may provide dramatic advances for traditional military roles and missions" (1). Robert Taylor was put in charge of the ARPA's computing services and in 1966, requested and was granted \$1,000,000 in funds to build a network of interlinked computers. To aid in this process, Taylor employed the services of Leonard Kleinrock and J.C.R. Licklider from MIT, both of whom are often referred to as inventors of Internet technology.

The ARPAnet, now called the internet, established nodes at various educational institutions nationwide. Although primarily used for military purposes, the internet was also used very early on in educational institutions for research and other educational purposes. Over the next 20 years, advancements were made in the types

of services the internet could provide, namely electronic bulletin boards and e-mail programs.

While the birth and development of the internet marked major technological advances in the 1960s, 1970s, and 1980s, the internet could only support text-only communication (2). In an effort to expand the capabilities of the internet, the CERN High Energy Physics Lab, in 1989, proposed the development of a system that could transfer many kinds of computer information, all of which were linked together (2). The end result of the CERN's proposed project was the World Wide Web (WWW), which included new features such as hypertext links, the use of URLs for addressing information, and early browser software such as Mosaic, while still maintaining the already developed functions of the Internet. It was not until the development of the Netscape Navigator browser software that the real potential of the Web in terms of its information transmission and retrieval capabilities was recognized.

The development of the Web has proven to alter many aspects of daily life. It is no longer necessary to leave one's home to purchase groceries or books, or to send flowers. College students can write entire research papers using information from the university's library without leaving the comfort of their dorm rooms. Tourists can obtain driving directions to nearly any destination in the continental U.S. with just the click of a few buttons. Communication between friends and/or relatives

living in different countries on different continents can occur in a matter of minutes. Life with Web technology is drastically different than what it was a decade ago.

Education is also evolving on many fronts as a result of Web technology. John Moore, editor of the Journal of Chemical Education, urges chemistry teachers in an October 2000 editorial to take an active role in deciding how technology will shape the future of chemistry education. He notes that the technology being built has the potential to "put [teachers] out of business" if we do not expend the time or energy to develop ways to incorporate it into the classroom (3). Technology, namely Web technology, is a reality and as David Brooks comments in his book entitled *Web Teaching*, "[it] is changing both what we teach and how we teach it" (2).

1.2 Why Invest Time in Developing Web-based Courses?

Within one and a half years after the development of the Netscape Navigator Web browser, there were 65 million users (2). Today, it is estimated that roughly 544 million people worldwide are Web users (4). Students, mainly high school and college level, constitute a large proportion of these Web users. With increasing comfort in using computers and Web technology, these students will begin to demand more internet-based course offerings (5). After all, web-based courses certainly broaden a student's course options by allowing more flexibility in his/her schedule. In addition, without the constraints of time and/or distance, web-based courses have the potential to make learning more convenient for a larger body of individuals. Among institutions of higher learning, online course offerings will be

seen as a competitive edge. In their article, Frank Newman and Lara Courturier contest that, in the not-too-distant future, a university's skilled use of technology to enhance student learning will determine its capacity to compete as an institute of higher learning (6). Therefore, educators must be willing to devote time to researching, developing, and teaching web-based courses if they wish to broaden their online course offerings and thus increase their competitiveness in the larger scope of post-secondary education.

The Internet contains a wealth of educational materials for use by teachers of all levels and in all disciplines. However, despite the amount of educational materials available on the Web, there is little published research concerning the effectiveness of using the Web as a teaching tool. Research studies conducted by Cooley, Park, and Porzio in the mid-1990s did show substantial learning gains when students used multimedia tools "actively and extensively" (2). However, the scarcity of published results in the field of online learning, particularly in the field of chemistry education, has elicited some negative opinions on the effectiveness of web-based instruction. Richard Zare, a professor at Stanford University, feels that web-based instruction "undervalues the influence of the instructor in the learning process" (7). A. William Johnson, a professor of organic chemistry, believes that a teacher's unique capability to help students understand, to teach them how to think, are "seldom accomplished using online learning" (8). The amount of research available in the field of online learning is not sufficient to combat soundly opinions such as those cited above. However, despite the lack of research, the World Wide Web is

here and will be used in instruction "regardless of what teachers think, feel, or do"

(2). If web-based instruction is to be proven a viable method of course delivery and effective in student learning, educators must take an active role to develop, implement, evaluate, and publish their work in this scarcely published field.

1.3 Applications of the Web in Chemistry Courses

The World Wide Web is primarily being used in chemical education and/or chemistry courses as a means of making course information and materials more accessible to students (9). The development of courseware packages such as *Blackboard* and *Web CT* have been widely accepted by instructors and successfully integrated into their courses. According to Sue Rodgers, coordinator of the Technology and Learning Center at San Jacinto College, over 1600 colleges, universities, and K-12 institutions have adopted *Blackboard Courseware* for use as an online instructional tool (10). Both *Blackboard* and *WebCT* offer online features such as discussion boards, e-mail, syllabus posting, quiz tools, assignment dropboxes, announcement forums, etc., all of which requires very little knowledge of HTML coding. In general, *Blackboard* and *WebCT* courseware have been favorably accepted by instructors and students because information can be made available rapidly and accessed conveniently any hour of the day or night (11).

Using the Web as a repository of information for students certainly has its conveniences, but according to Paulisse, it offers "no pedagogical advantages over hard copies of the same stuff" (9). In other words, learning gains do not occur

simply as a result of easy information access. Marcy Towns and colleagues contend that to maximize the potential of the Web as an instructional resource, the Web must become a tool for actively engaging students in the learning of chemistry, rather than a tool for the passive dissemination of information (12).

Within the last decade, the field of chemistry education has seen the birth of several projects aimed at using the Web as means for actively involving students in the learning of chemistry concepts. Some of these projects, like Physical Chemistry Online (PCOL), use the Web as a supplemental component of the course. Students at four remote institutions perform laboratory work at their home institutions and subsequently use the Web to share data and collaborate as a team in completing a series of lab experiments (12). Other projects use the Web as a primary mode of course delivery, offering entire courses online. In 1995, the University of Nebraska-Lincoln offered a professional development course to high school teachers, which dealt with the use of small scale chemistry in high school teaching (13). Currently, the National Science Foundation funds 18 one-credit hour courses offered online to chemistry teachers, in an effort to increase their chemistry content background (2). Many educators, like M.J. Patterson at Brazosport College, have undertaken the conversion of their own chemistry courses into web-based formats, without much funding and without much published research to guide them along the way (5). The work and the results of some of these efforts will be highlighted periodically throughout the remainder of

the literature review.

1.4 Student Learning in Web-based Courses

The body of research concerning the effectiveness of web-based courses and the learning outcomes that occur within this instructional setting is scarce.

Nevertheless, educational researchers wishing to develop web-based courses and students considering enrollment in web-based courses would like an answer to the question “How effective is web-teaching?” Brooks contends that it is still too soon to answer this question; however, he does state that “early results suggest strongly and consistently that students in Web courses learn about the same as learners in conventional courses” (2). Scott Wegner, associate professor of educational administration at Southwest Missouri State University, conducted a two-semester study on the effectiveness of web-teaching on student achievement and found no significant difference between student achievement in the web-course versus the traditional face-to-face course (14). At first glance, this finding may seem dismal, but the results can also be interpreted as evidence that the Web-format does not necessarily hinder student learning. Research conducted by Mark Rossman at Capella University emphasizes the importance of student interaction and discussion as components in web-based courses in saying that “learners...seemed to learn much from the responses of other learners” and valued this aspect of their web-based course (15). Furthermore, evidence from *Learning Networks* suggests that electronic conversations are as effective, if not more effective, than in-class discussions (2). Do these electronic conversations lead to greater student

achievement? Not necessarily. However, Brooks contends that the most effective Web-based learning occurs when students feel a sense of support and camaraderie from among their peers, which can be supported effectively by the World Wide Web through electronic conversations (2).

At the University of Nebraska-Lincoln, researchers found a large degree of variation in the quality and quantity of student work in their web-based course (13). Some students demonstrated their learning in great depth while others seemed to exert little to no effort in completing assignments and projects. This observation has lead researchers in the field to conclude that Web-based courses lend themselves more favorably to certain populations, namely self-regulated learners (2). However, this realization has made evaluating the effectiveness of web-teaching all that much more difficult. For the self-regulated learner, web courses are very effective in terms of student learning. For the poor self-regulated learner, web courses can mean academic disaster. With both types of students in any given web-based course, comparing student learning outcomes in the web-based setting to those in the traditional classroom setting has left educators with some difficulty in answering the question “How effective is web-based teaching?”

1.5 The Web-based Learner

To be able to analyze the effectiveness of web-based teaching, it is necessary to become tuned to the types of learners enrolled in the web courses one is teaching. In general, the students in a web course can be classified in two ways: good self-

regulated learners and poor self-regulated learners. Characteristically, good self-regulated learners are goal oriented, motivated, self-disciplined. They seek to understand ideas and concepts rather than memorize and recall facts. Self-regulated learners actively pursue their own learning and will take necessary measures to ensure that learning is occurring (e.g. schedule time to study, seek out tutors). It should be no surprise then, that these students have much more success in web courses than the poor-self regulators, who lack the aforementioned skills (2).

Fortunately, self-regulation is a teachable skill and one that is not dictated by intelligence (16). In a web-based course, where the learner's ability to self-regulate plays a large part in his/her success in the course, it is ever so important to find ways to incorporate and promote self-regulated learning in the curriculum. In designing a web-based curriculum, instructors should promote content mastery rather than task mastery. Assignments should be challenging, and should allow students opportunities to make choices about their learning (2). In addition, students need to see that success in the web-based course is within their control and related to the effort put forth in completing the Web tasks (2). In devising Web tasks and assignments that promote and encourage self-regulated learning, instructors are hopefully helping students to hone the skills that are necessary for success in web-based courses. Ultimately, attrition rates in distance learning courses should decline, students should fare better in web-based courses, and the effectiveness of these courses can be analyzed more closely.

1.6 Formats of Web-based Courses

Web-based courses can be designed in a variety of formats. In some cases, such as the Physical Chemistry Online project, the Web is used as a resource for facilitating collaboration among students in various remote locations. Students still have class meeting dates and times, and use the Web as a communication tool within this setting. In other web-based courses, the Web is used for delivery of all course content and materials. In this format, all interaction, be it student-student or student-instructor, occurs via the online medium. In a somewhat mixed design, some courses have been designed in a “distributed learning” format that affords the advantages of both online learning and traditional face-to-face instruction. In a distributed learning course, the majority of the course content is delivered and accessible via the Web, while a small portion of the content is delivered in the face-to-face format. According to Kochtanek, the distributed learning format has its advantages because it allows for both asynchronous and synchronous delivery of course content and materials (17). Although the distributed learning format has the potential to limit the number of participants, it is speculated to have its advantages when it comes to student retention (2). Choosing the format for a web-based course is ultimately at the discretion of the instructor. However, the format chosen should be deduced in conjunction with the intended audience for the course and the learning goals to be achieved by participants in the course.

1.7 Designing the Content of a Web-based Course

The use of the Web and other multimedia sources in courses certainly has its conveniences to both students and instructors alike. However, the Web technology itself is not likely to lead to increased learning gains on the part of the student. Perhaps David Brooks, in describing the web as a medium for instruction, provides the best advice to those developing curricula for web-based instruction. He warns that even though research shows that using technology extensively and exclusively can lead to increased learning gains, technology alone does not enhance learning; “active learning is the key” (2). Therefore, when developing the curriculum for a web-based course, time should be spent in designing assignments that employ active learning strategies. The extent to which students are engaged in active learning depends largely on the tasks assigned to them by the instructor. To promote active learning, assignments should be engaging--in chemistry, assignments should be both physically and mentally engaging. Students should be forced to think critically about ideas and concepts in asking and finding answers to important questions. According to M.J. Patterson, students must also have a means to interact with and among their peers to gain insight and construct desired understandings, as well as to combat feelings of isolation (5). The Web and its many capabilities can certainly provide a forum that promotes active learning. It allows students to gather necessary research, to respond and transmit information, to make choices, to communicate with their peers, and to think critically and deeply about course material.

1.8 Technical Aspects of Web-course Design

A variety of technology applications are available for facilitating the conversion of a traditional face-to-face course into an online course. In addition, researchers who have undertaken such conversions have gathered numerous experiential details in helping others to undertake this technological leap.

1.8a Platform Compatibility

In a web-based course, students and instructors alike will be transmitting information back and forth via the online medium. Some people will be using a PC platform for information transmittal and retrieval, while others will be using the Macintosh platform. For ease of communication in a web-based course, only cross-platform software should be used for generating and transmitting information (2). Luckily, most software developers have begun writing for cross-platform compatibility; therefore, with a little background research, choosing and using cross-platform software in a web-based course eliminates the need for platform restrictions and ultimately opens up the course for both audiences of platform users.

1.8b Text

The amount of course materials developed for a web-based course will be profuse. Text materials will constitute a large portion of these course materials and, therefore, the mode for handling the text should be thought about early in the development process. Brooks advises web-course developers to create text using a word processing program and subsequently use a conversion software such as

Adobe *GoLive* or *Dreamweaver* to format the text as though it will appear on the Web page (2). These programs such as *Dreamweaver* or *GoLive* allow the user to visually design the layout of a web page (which includes text) while automatically encoding the HTML tags that correspond to one's chosen format. Therefore, web pages can be created rapidly and easily without requiring the user to possess extensive knowledge of HTML coding, which in the past, has been a great hindrance to designing Web pages.

1.8c Non-text Materials

Non-text materials, which include videos, graphics, and sound clips, are often included as components of web-based courses. Because many students will be accessing course materials at home or off-campus and are “at the mercy of web traffic”, Brooks warns web-course designers to be cautious of the amount of these non-text materials used on the course website (2). Most times, these non-text materials have longer download times as compared to text, which when exacerbated by low-memory computers or web traffic, can cause students to become frustrated with the course. To combat lengthy download times for modem based machines and to curb student frustration, CD-ROMs are often used to deliver these non-text materials.

1.8d Courseware Packages

Courseware packages such as *Blackboard Courseware* and *WebCT* are ideal for managing much of the content in a web-based course. Using either of these

courseware packages, instructors create their own course website which can house learning materials needed by students enrolled in the course. These courseware packages also offer other online instructional tools such as announcement boards, e-mail, syllabi posting, online discussions, grade books, digital dropboxes, --all of which can be done with minimal knowledge of HTML coding. With such a vast array of available options, David Brooks urges designers of web-based courses to take advantage of the resources these courseware packages offer by using either *Blackboard* or *WebCT* in online courses for management of course materials (2).

1.8e Electronic Conversations

Web-based courses eliminate the possibility of face-to-face discussion between and among students and instructor. Many view this face-to-face interaction as vital and irreplaceable. While certainly vital, face-to-face discussion is not the sole way to promote interaction among students in a class, nor has it been proven to be the best way. Research in the area of graduate and adult learners has turned up evidence suggesting that “electronic conversations are every bit as effective as in-classroom discussion, and often much more so”(2). Although the research on the effectiveness of electronic conversations in undergraduate courses is still inconclusive, the inclusion of an electronic discussion component into any web-based course is necessary to allow students to question and process new knowledge, to allow for exchange of ideas, and to combat feelings of isolation that are typically encountered in web-based courses.

Electronic discussions can be either synchronous or asynchronous in form.

Synchronous discussions require all participants to interact and converse online at a set date and time. In other words, students discuss in real-time. With asynchronous discussions, students discuss a given topic by responding and reading their peers' responses at a time convenient for them (2). Although asynchronous discussions offer a bit more flexibility for students, both types of discussion have their advantages. The courseware packages discussed in section 1.8d support both synchronous and asynchronous discussion. Synchronous discussions are typically facilitated via whiteboards or chat functions, while asynchronous discussions are most commonly conducted via listservs, threaded discussion boards or e-mail.

1.9 Technical Issues and the Web-based Learner

Based on past experience in developing and implementing web-based courses, Liu, Walter, and Brooks urge web-course developers, in their article entitled "Delivering a Chemistry Course over the Internet", to be aware of the vast array of computer skills that students in web-based courses possess (13). These researchers found that some students in their courses were technologically adept at handling any computer-oriented task given to them. Others had very little skill when it came to software. Some even complained of being limited in terms of computer access despite the fact that the course was advertised as being web-based.

In the 21st century, it is safe to assume that most students will have some experience using the Web. However, Brooks warns that it is possible to overestimate students'

ability when it comes to using computer technology (2). Therefore, web-course instructors should certainly anticipate a method for managing students' wide range of computer skills and capabilities. Detailed instructions on the use of important software may be enough to combat the problem. Perhaps some sort of technology pre-test should be given prior to registration where prospective students are required to demonstrate their computer skills. Regardless of how this aspect of web teaching is handled, the issue requires forethought in order to avoid an excessive expenditure of time in basic technology instruction and to circumvent frustration by students and instructor alike.

1.10 The Problem

As evidenced by the research presented previously in this literature review, the practice of using technology to deliver chemistry courses in post-secondary education is opening new doors in the field of chemistry education. The use of Web technology has the capability to extend learning experiences beyond the typical notion of "classroom" and to a broader audience of individuals.

At Miami University, only a limited number of web-based courses are offered – an introductory psychology course, a physics course, and an information management course. In Spring 2001, the Miami University's Center for Chemistry Education was funded by the Ohio Board of Regents to convert an existing undergraduate chemistry course, "Chemistry with TOYS" (CHM 205), into a web-based course and to extend this online conversion to the graduate "Chemistry with TOYS" course

(CHM 625). The “Chemistry with TOYS” course is a product of the nationally-recognized “Teaching Chemistry with TOYS” project that began in 1986. The project’s aim was, and currently is, to increase elementary and middle school teachers’ understanding of fundamental chemistry principles through the use of hands-on activities which incorporate the use of toys and common novelties. The overarching goal of the online “Chemistry with TOYS” course remains the same, despite the change to an internet-based delivery system.

The technology conversion of the “Chemistry with TOYS” course involves four components:

- Development and testing of the course curriculum and any supporting materials
- Development and testing of a course website
- Teaching the pilot offering of the course
- Evaluation of the course in terms of student learning and satisfaction

The methods employed as well as the research generated in completing each of the above project components are outlined in the following three chapters of this document.

Chapter 2: Methodology

This chapter outlines the development and testing of the CHM 205/625 course content, supporting materials, and course website.

2.1 Overview

In the past decade, the World Wide Web (WWW) and its accompanying conveniences of rapid information transmission has incited chemistry educators to find ways of incorporating Web technology into their classrooms. Most commonly, chemistry educators use the Web as a means for convenient dissemination of course materials, such as syllabi or assignments (9). However, the CHM 205/625 course, in accordance with the most recent trends in Web course design, aims to use the Web for actively engaging students in the learning of chemistry principles as a means to help students ask and answer pertinent questions, to force them to think critically about the material, and ultimately, to help them build a thorough understanding of a variety of fundamental chemistry principles.

2.2. Framing the “Chemistry with TOYS” Course

In the field of chemistry education, the development, implementation, and evaluation of web-based courses to date has been minimal. Fortunately, educators across a multitude of other academic disciplines have begun to develop, implement, and evaluate web-based courses in their curricula. The literature generated from the work of these educators served as a starting point for the initial stages of the technology conversion and the outlining of the CHM 205/625 web-based format.

2.2a. Goal Setting

In undertaking the technology conversion of the “Chemistry with TOYS” course and development of companion course materials, four broad goals were outlined as a guide for the work to be done. These goals included:

- To use the Web for effectively delivering the chemistry content for the CHM 205/625 course;
- To make the CHM 205/625 course materials accessible anytime, anywhere with minimal frustration;
- To engage students in active learning via online quizzes, do-at-home hands-on chemistry investigations, and online discussion; and
- To encourage regular interaction with the course materials through the use of frequent, yet realistic, deadlines.

2.2b. Audience

The target audience for the CHM 205/625 course is defined as elementary and middle school teachers, both pre-service and in-service. In any given semester, the “Chemistry with TOYS” online course may be comprised of both college undergraduates training for the teaching profession and practicing teachers. These two seemingly similar audiences are actually very different in terms of the ideas and experiences they bring to a class. The in-service teachers fall into a special subset of adult learners who bring with them strong ideas and opinions of how courses should be taught, how students should be evaluated, and how learning occurs. In addition, these adult learners often have a plethora of insight and experiences, both

personal and professional, which they are usually willing to share with the class at large as learning opportunities for all. Finally, in addition to their jobs, in-service teachers very often have spouses and/or families that, in addition to coursework, require their time and attention.

The pre-service teachers who are very often traditional college undergraduates, are working to build their repertoires of teaching experiences. In addition, this group's primary responsibility tends to be school, rather than a job or family.

2.2c. The Web-based Format

Based upon the intended audience as well as the goals for the course, a distributed learning format was chosen for the CHM 205/625 web-based course. The distributed learning format, as defined previously, employs a mixed design of both online learning and engaging face-to-face instruction. In the "Chemistry with TOYS" online course, approximately 80% of the course content is delivered through the course website, with the remaining 20% being delivered in three full-day, face-to-face class sessions held periodically throughout the semester. These face-to-face class sessions afford students the opportunity to conduct chemistry investigations that require the use of an actual laboratory facility as well as serve as an informal assessment time for monitoring the students' progress with the content being delivered on the Web. In choosing the distributed learning format for the CHM 205/625 course, the conveniences of online learning and the benefits of face-to-face classroom instruction are blended into the course structure.

2.2d. Establishing the Course Curriculum

Prior to Spring 2001, Miami University offered both an undergraduate (CHM 205) and a graduate (CHM 625) “Teaching Chemistry with TOYS” course for pre-service and in-service elementary and middle school teachers. In both courses, a curriculum had been established whereby students were engaged in investigating fundamental chemistry principles through the use of many household items and common toys. The curriculum designed for each of these aforementioned courses served as a guide in outlining the curriculum for the “Chemistry with TOYS” online course.

The content for the CHM 205/625 course was divided into units, with each unit corresponding to a different fundamental chemistry topic (See Table 2.1). For each unit, students complete a number of different assignments on a particular fundamental chemistry theme. Through this unit classification scheme, students logically progress from easier chemistry concepts to more difficult ones, all within the framework of manageable sections rather than one large chunk.

In building the framework for the course, it became apparent that some assignments required visual aid or verbal explanation to complete successfully. To incorporate these visual and verbal components into the course, a CD-ROM of Quicktime videos was created for activities or explanations that were vital to student understanding, yet challenging to convey via the online medium.

Table 2.1 “Chemistry with TOYS” Online Units

Unit	Unit Name
I	Macroscopic View of Matter
II	Physical Effects of Energy on Matter
III	Density
IV	Particle Nature of Matter
V	Water
VI	Mixtures and Solutions
VII	Chemical Interactions

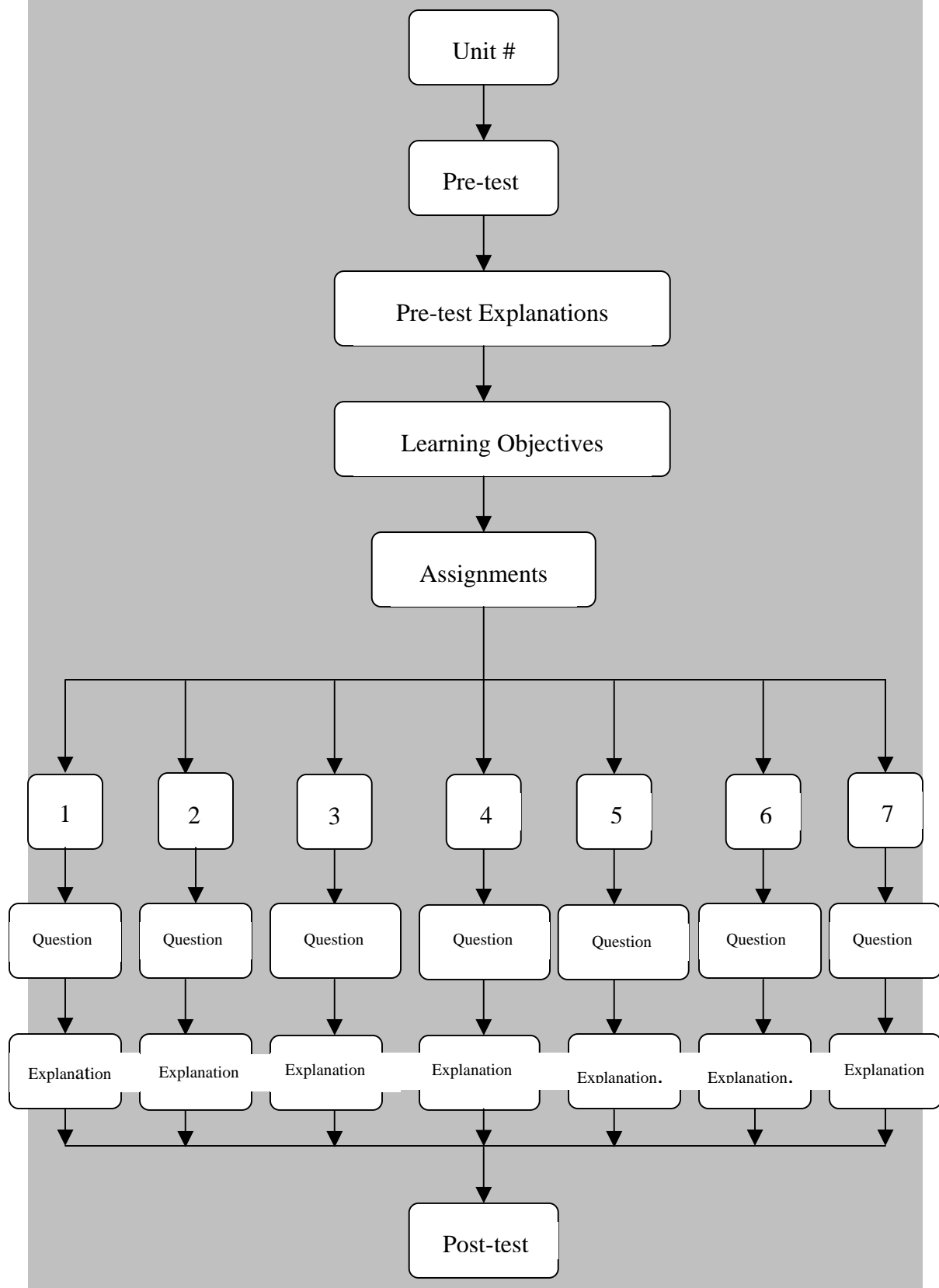
2.3 Initial Drafting of the Course Curriculum

The curriculum for the “Chemistry with TOYS” online course was designed according to the "backward design process", a method outlined in Grant Wiggins' and Jay McTighe's book entitled *Understanding by Design* (18). According to this method, curriculum designers are urged to abandon the common practice of beginning curricular design with favorite lessons or "time-honored activities" and instead, begin by first deriving the desired student learning outcomes. Also, rather than waiting until the conclusion of a unit to think about assessment, assessment strategies are addressed as the learning outcomes are developed in order to clearly define acceptable evidence that the learning objectives have indeed been met. The final step in this backward design method is to plan activities and learning experiences that coincide with both the learning objectives and the assessment techniques. In following this curricular design sequence in which designers switch

from being activity-centered to being goal-centered, the authors contend that there is "greater coherence among desired results, key performances, and teaching and learning experiences", which ultimately leads to better student performance (18).

Wiggins' and McTighe's backward design process was used in the development of each of the seven units for the "Chemistry with TOYS" online course. For each unit, desired student learning objectives were decided first, followed by the assessment strategies, and lastly, the individual assignments and activities that coincided with both the desired results and assessment techniques. The "Chemistry with TOYS" online components are outlined in Figure 2.1. The development of these course components is described in Sections 2.3a to 2.3c in detail.

Figure 2.1 Outline of the Chemistry with TOYS Online Components



2.3a. Learning Objectives

Pedagogically speaking, learning objectives are designed to be the "road map" for curricular design. Once determined, the learning objectives serve to guide all teaching and assessment strategies that are incorporated into the curriculum.

A series of learning objectives were outlined for each of the seven units in the CHM 205/625 course (See Appendix A). The learning objectives for Unit 1: Macroscopic View of Matter are shown in Figure 2.2 as they are presented to the student online.

Figure 2.2 Unit 1 Learning Objectives

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Unit 1: Learning Objectives

Unit 1: Macroscopic View of Matter

- [Pre-Test Instructions](#)
- Learning Objectives**
- [Assignments and Materials](#)
- [Online Discussion](#)
- [Post-Test](#)
- [Unit 2: Physical Effects of Energy on Matter](#)
- [Unit 3: Density](#)
- [Unit 4: Particle Nature of Matter](#)
- [Unit 5: Water](#)
- [Unit 6: Mixtures and Solutions](#)

Student should be able to:

1. Provide answers and/or examples for the following questions: What is chemistry? What are chemicals? What do chemists do? What is the scientific method? How do scientists use the scientific method as a problem solving technique?
Assignment 1.
2. Define matter as anything that has mass and takes up space and identify examples of matter based on the definition and sensory observations.
Assignments 2, 3, and 4.
3. Distinguish among the three states of matter based on sensory observations.
Assignments 2, 3, and 4.
4. Distinguish among the three states of matter by comparing and contrasting the physical properties of each state (shape, volume, and compressibility).
Assignments 4, 5, and 6.
5. Draw the three states of matter as they exist at the particle level and specify how the spatial arrangement of the particles in each state accounts for their behavior.
All assignments point toward this understanding, with Assignment 7 being the culminating activity.

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2.3b. Assessment Strategies

In the development of the first unit for the CHM 205/625 course, it was apparent that the web-based format would necessitate a variety of assessment strategies for monitoring student learning before, during, and after completing each unit in the course. In addition, because the web-based format affords students access to any and all resources available to them, the assessment questions need to be conceptually based, in which application of learned concepts is emphasized rather than recall of chemical facts and definitions. The assessment methods employed in the “Chemistry with TOYS” online course are discussed below.

Pre-test

In order to assess student understanding prior to completing any work for a given unit, an online multiple choice pre-test was created for each of the seven units. By focusing on understanding of concepts rather than recall of facts or definitions, the pre-test questions themselves seek to uncover students' conceptual understanding of chemistry principles. In creating the pre-test questions, an attempt was made to accommodate various learning styles through the use of drawings, graphs, photographs, and words (See Figures 2.3 and 2.4)

An online program call Hot Potatoes was used to deliver the pre-test questions via the Web (19). This software, which allows the user to custom design online quizzes in a variety of formats, is designed to be interactive. When answering a question, students are required to answer the question correctly before moving to the next

question. If the question is answered incorrectly initially, the student is prompted to keep trying until they have answered the question correctly. After completing the pre-test, students are informed of which questions they answered correctly on the first try and which questions required more than one attempt. In doing so, students hopefully become better aware of their conceptual strengths and weaknesses concerning the material to be covered in the upcoming unit.

Figure 2.3 Example of Pre-test Question for Unit 1

Unit 1: Macroscopic View of Matter Pre-test
Multiple-choice exercise

◀ 3/7 ▶

3 Which of the drawings below best describes what you would observe if the liquid water from container 1 was poured into container 2?

The diagram shows a 20 mL test tube on the left and a 50 mL beaker on the right, with an arrow pointing from the test tube to the beaker. Below this are four options labeled a, b, c, and d, each showing a 50 mL beaker with a different amount of liquid inside:

- a. The beaker is nearly full, with the liquid level at approximately 45 mL.
- b. The beaker is about half full, with the liquid level at approximately 25 mL.
- c. The beaker is about one-third full, with the liquid level at approximately 15 mL.
- d. The beaker is about one-fifth full, with the liquid level at approximately 10 mL.

A Container a.
 B Container b.
 C Container c.
 D Container d.

Figure 2.4: Example of Pre-test Question for Unit 1

Unit 1: Macroscopic View of Matter Pre-test
Multiple-choice exercise

5/7

5 Which of the following drawings represents the particles of helium gas inside a balloon?

a. b. c. d. e.

A Balloon a.
 B Balloon b.
 C Balloon c.
 D Balloon d.
 E Balloon e.

When a student completes a pre-test for a given unit, two things occur:

- the student is informed of which questions he/she answered incorrectly and is redirected to a web page where he/she can view explanations for each of the answers
- the student's results are automatically sent to the instructor via e-mail, informing him/her of which questions the student answered correctly on the first try and which questions required multiple attempts. The results page has also been custom designed to include the order of the choices the student chose in answering each multiple choice question. This page is helpful for identifying trends in concept deficiencies or possible error in the questions themselves (See Figure 2.5)

Figure 2.5 Student Pre-test Results Sent to Instructor

The screenshot shows an email interface with a blue header bar containing buttons for 'Reply', 'Reply All', 'Forward', 'Delete', and 'Put in Folder...'. A link for 'Printer Friendly Version' is also present. The main content area is white and contains the following text:

Below is the result of your feedback form. It was submitted by mbh () on Wednesday, May 22, 2002 at 11:07:24

Exercise: Unit II: Physical Effects of Energy on Matter Pre-test

ResultData: Student name: mbh
First guess correct score: 4 of 6 (66%)
First guess correct on questions 1, 2, 3, 4

Question 1: clicks: 1; B
Question 2: clicks: 1; C
Question 3: clicks: 1; D
Question 4: clicks: 1; E
Question 5: clicks: 5; B C D E A
Question 6: clicks: 2; B C

Start_Time: Wednesday, May 22, 2002 12:05:50 PM

End_Time: Wednesday, May 22, 2002 12:07:23 PM

In addition to providing the student with an advance awareness of his/her understanding of the content to be covered in a given unit, the pre-test also serves as a baseline for the instructor in evaluating student's prior knowledge of a topic.

Activity Assessments

In a web-based course where the instructor does not regularly meet face-to-face with students, it is especially vital to monitor student progress frequently as they complete the coursework to ensure that students are building the understandings that the assignments and activities are meant to illustrate. In the "Chemistry with TOYS" online course, students complete a short essay question for each of the

assignments or activities in a given unit which is then submitted to the instructor online via the course website. The instructor uses this information to monitor student understanding from assignment to assignment and to provide immediate feedback to the student should his/her understanding be misguided.

Post-test

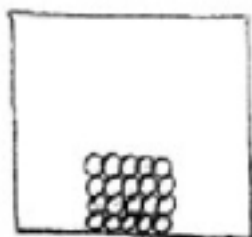
Once the student completes all assignments/activities for a given unit, he/she is given a post-test to assess his/her understanding of the chemistry covered in the unit. The post-tests require students to integrate and apply concepts from the entire unit and to illustrate their understanding in a variety of ways, including words, graphs, illustrations, and design of new experiments. Figure 2.6 shows four of the post-test questions for Unit 1.

Figure 2.6 Unit 1 Post-test Questions

Unit I: Macroscopic View of Matter

Post-test Questions

1. Much of what you encounter daily is classified as matter. However, sound is **NOT** classified as matter. Based on what you have learned from this unit concerning matter and its states, explain why sound is **NOT** considered to be matter. In addition, propose a method by which you could prove that sound is **NOT** matter.
2. You have been given a bottle of perfume/cologne. Shortly after opening the bottle, the scent of the perfume/cologne is detected by one of your friends who is several feet away from the spot in which you opened the bottle. Explain how and why your friend detects the scent from several feet away when the bottle is opened?
3. The drawing shown below represents a side view of a closed container that contains 20 atoms of copper at room temperature and pressure.



- a. Draw the atoms after the copper has melted.
- b. Draw the atoms after the liquid copper has all evaporated.

Note: Each copper atom is represented by one circle.

4. A tractor trailer truck weighing 5 tons has overturned on a major interstate and is resting on its side. Based on what you have learned from this unit, propose a method for getting the tractor trailer back on its 18 wheels. Explain why your method will work.

After completing the post-test, the student submits his/her work via fax, U.S. mail, or hand delivery, and the instructor communicates individually with each student via e-mail regarding his/her performance.

2.3c. Assignments and Learning Experiences

After outlining the desired learning outcomes and assessment strategies for a given unit, the final step in Wiggins' and McTighe's "backwards design process" is to deduce the learning experiences that will afford students the opportunity to build the desired understandings and successfully provide evidence of their understanding. In the "Chemistry with TOYS" online course, the learning experiences can be categorized in the following ways:

- completion of hands-on chemistry investigations and subsequent completion of short essay questions regarding the investigations,
- viewing a Quicktime video from the course CD-ROM and subsequent completion of an online essay question regarding the video,
- participation in online discussions
- attendance at three full-day Saturday class sessions.

Hands-on Chemistry Investigations

The majority of the learning experiences for a given unit require the student to complete a series of hands-on chemistry investigations in the home and to subsequently respond to an assessment question via the course website. The hands-on investigations allow the students to be actively engaged in building their

understanding of chemistry concepts, a central goal of all of the “Chemistry with TOYS” courses, regardless of format.

The activities used in the CHM 205/625 online course were adapted from those previously used with the face-to-face version of the course. A list of the lessons and the appropriate reference citations are provided in Appendix B.

As part of the course materials, students purchased a TOY kit which contained a book, a collection of supplemental lessons, a CD-ROM, and a collection of toys and materials that the students would probably not have available in their homes or dorm rooms. Supplemental directions for completing each of the chemistry lessons are delivered via the course website (See Figure 2.7). Specifically, these supplemental instructions serve to guide the student in completing each of the investigations by telling him/her the location of the print source, describing the needed materials, and highlighting the parts of the activity to be completed in accordance with the printed source of the activity.

Figure 2.7 Supplemental Instructions for “Feely Balloons” Assignment

[< back to CHM205 Blackboard](#) | [Questions? E-mail instructor](#)

[Toys Online Units Home](#) > [Unit 1: Macroscopic View of Matter](#) > [Assignments and Materials](#) >

Unit 1: Feely Balloons

Unit 1: Macroscopic View of Matter

- [Pre-Test Instructions](#)
- [Learning Objectives](#)
- [Assignments and Materials](#)
 - 1 Feely Balloons**
 - 2 [Identifying Substances by Smell](#)
 - 3 [What is Matter?](#)
 - 4 [Crystal Pictures](#)
 - 5 [Properties of Matter](#)
 - 6 [Particle Nature of Solids, Liquids, and Gases](#)
- [Online Discussion](#)
- [Post-Test](#)

[Unit 2: Physical Effects of Energy on Matter](#)

[Unit 3: Density](#)

[Unit 4: Particle Nature of Matter](#)

[Unit 5: Water](#)

[Unit 6: Mixtures and Solutions](#)

Activity Instructions

1. Find the Feely Balloons Activity in the Unit I Monograph.
2. Gather the Materials listed under For Getting Ready and For the Procedure.
3. Complete the tasks listed under Getting Ready.
4. Because you have prepared the balloons, you will need to find a willing friend to participate in doing the activity. You will assume the role of teacher and your friend will be the student.
5. Complete the Procedure as it is written.
6. Read the Explanation for the activity.

Activity Assessment

Answer the following assessment question in the text box provided and submit your response electronically.

- a. What properties of the solids help one to identify the contents of the four balloons?
- b. Would it be easier or more difficult to identify the contents of the balloons if the contents were liquids instead of solids? Explain.

Type your answer below, in sentence form.

After completing a particular assignment within a unit, the student answers a short essay question regarding the assignment and submits his/her response to the instructor via the Web. The instructor can then gauge whether sufficient understanding of concepts has occurred.

Quicktime Videos

In developing the learning experiences for the course, there seemed to be a small number of activities and/or explanations that were vital to student understanding, yet difficult to convey via the online medium. To ensure that students received all of the content necessary to build a thorough understanding of a given topic, a CD-ROM of Quicktime videos was created to illustrate or convey some of these more challenging activities or explanations. Placing these videos on a CD-ROM rather than on the course website itself eliminates the long download times that are often encountered when viewing videos via the Web. In the course, students are periodically asked to view a video from the course CD-ROM and subsequently answer an online assessment question that pertains to the understanding that the video was meant to convey.

Online Discussion

Research in the field of learning theory suggests that learning is not a solitary activity. Therefore, in a web-based course where students complete much of the work in their own households at their own convenience, it is vital to create opportunities for students and instructors to interact with one another so as to avoid

feelings of isolation. In the “Chemistry with TOYS” online course, weekly online discussions give students and instructors an opportunity to interact with one another as well as provide an alternate way of assessing the learning that transpires over the course of a given unit.

The online discussion questions themselves center around placing the learned chemistry principles into a real-world context. A discussion question is posted weekly on the discussion board, and students post responses in the allotted time period to either the question itself or to the response of another student. In addition, the instructor or perhaps another student, could also post a response as a means of “steering” the discussion in a particular direction or as a means of widening the discussion to a new, yet related, topic. Regardless of the format, the online discussion component of the course is meant to be a way for students to communicate with one another and with the instructor as they build a working knowledge of a variety of chemistry concepts.

Saturday Class Sessions

In designing the curriculum for this course, it became apparent that several learning experiences would require the use of a laboratory facility and laboratory materials. Other learning experiences would be difficult or unsafe to do at home for the first time without professional supervision. Incorporating these learning experiences into the “Chemistry with TOYS” online course necessitated face-to-face instruction between the instructor and students. To this end, three Saturday class sessions were

incorporated into the online course as a time to complete the kinds of hands-on chemistry investigations described above.

2.4 Preliminary Design of Course Content

During the preliminary design stage of development, each of the “Chemistry with TOYS” units was organized into a template that was readable and understandable to reviewers and editors. The template was designed in a manner whereby reviewers and editors could understand the layout of each unit and see the logical progression from one unit to the next.

2.5 Pre-Course Review and Testing

Once packaged into a preliminary design, each of the “Chemistry with TOYS” units was reviewed by Mickey Sarquis for accuracy, appropriateness of content, and pedagogy. Revisions were made to each of the units based upon the review.

Each of the units then underwent microtesting, an evaluation technique in which the procedural instructions for an experiment or activity are tested by members of the target audience for whom the materials are being developed (20). Using this technique, the “microtester” is given only the written document as a guide for completing the activity—no other guidance is provided by the content developer except in cases where the tester is going to harm him/herself. The developer observes the microtester as he/she uses only the written document to complete the activity being tested, documenting the process as the tester proceeds working

through the activity. For the CHM 205/625 content materials, the microtester completed all portions of a given unit as she understood them from the directions, answering all questions and documenting any confusion or errors in the written document. Following the testing, I, as the content developer, interviewed the microtester for additional insight and suggestions on improving the online unit materials. The written documents for the course were then revised based upon the results of the microtesting to bring the written documents to the alpha draft stage of development.

By the alpha stage of development, all major content components of the online course had been drafted, microtested, and revised. Each of the seven online units had been assembled into a preliminary design and was ready for external review.

2.6 External Review

Dr. Jerry Sarquis, a chemistry content expert who was not involved in the initial development of the course materials, reviewed the course units following the pre-course internal review and microtesting procedures. This external review resulted in important word-level changes that added to the clarity and precision of the content in each unit.

2.7 Technical Aspects of the Course Website

With the pedagogical aspects and course content materials prepared, the attention was shifted to the technical aspects of the course website and to ensuring its

usefulness as an instructional tool. It was important that the website's navigational components be clear, logical, and flexible to ensure that students knew where they were at any location on the website, were able to stop and restart their work, and were able to back up or jump ahead as needed. We also worked to ensure that students with various processing styles (i.e. the skimmers, the detailers or random readers) were able to successfully use the course site.

In building the course website, we split the access between Miami University's (MU) Blackboard Courseware for general course management functions and the Center for Chemistry Education's (CCE) hostway website which offered flexibility and pedagogical aspects otherwise unavailable through Blackboard. MU Blackboard is used for the organization of course information such as the syllabus, for instructor and student contact information, for e-mail, and for facilitating the asynchronous discussions. The part of the CCE's hostway website that houses the CHM 205/625 course was developed using Dreamweaver software, a professional visual editor for creating and managing websites. This website houses the majority of the content for the course. These two components, MU Blackboard and CCE's hostway website, function together in delivering the course content and in incorporating all the anticipated facets of the course into a manageable and useful course site.

2.8 Microtesting the Course Website

The microtesting technique developed by Sarquis and Storer for testing written documents was adapted for application to the new web format (20). Before we undertook this evaluation, we also explored an evaluation method used by Indiana University web development services (21). The microtesting process used involves the evaluator observing a member of the target audience working through a set of tasks that require the manipulation of information and navigation through the course site. The evaluator observes and documents the user's navigational strategies in completing the tasks at hand.

Because the format and style for all units were essentially the same, we decided to begin the microtesting with Unit 1 and assigned the tasks listed in Appendix C. After the initial microtesting, revisions to the website and plans for subsequent units were made.

Also after the initial microtesting and subsequent revision, a second and third round of microtesting were undertaken with three units loaded onto the website. This microtesting phase was designed to uncover any issues related to disorientation or confusion resulting from the added material on the web. Revisions were again made to the website based upon the findings from these two rounds of microtesting.

At this point, we involved three individuals with past experience in web-based courses. These individuals were able to make suggestions and troubleshoot

possible problems, based upon their past experience with web-based courses. In addition, these “outside microtesters” used their own computers, allowing the designers to be sure that the website was structurally compatible with multiple kinds of computer systems varying in system speed, monitor size, memory, etc. This final testing showed that no additional changes needed to be made to the website. At this point, the remainder of the course content was loaded onto the website.

One final testing of the website was conducted to ensure that all links were active and functioning properly and was completed before the site was opened for student use in Fall 2001. This final testing revealed approximately five misplaced links, but the overall structure and organization did not need to be altered.

Chapter 3: Pilot Testing of CHM 205/625

3.1 Overview

The “Chemistry with TOYS” web-based course underwent initial pilot testing during the Fall 2001 semester with a mixed audience of undergraduate and graduate students. Sections 3.2. through 3.8 discuss some successes and challenges encountered during the first offering of CHM 205/625 in the web-based format. Recommendations for future course offerings are highlighted in Section 3.9.

3.2 Audience Analysis

The audience for the pilot CHM 205/625 course was comprised of both pre-service education majors taking the course for undergraduate credit and in-service teachers taking the course for graduate credit. At the onset of the course, ten students were enrolled in the course: seven undergraduate students and three graduate students. The small audience was advantageous in tackling a new course, especially a web-based one, where so many variables were unknown. In addition, small audiences are to be expected when offering a new course, and according to Patterson, instructors must be allowed to teach the course with a small audience to establish its viability (5). With 10 students enrolled, Miami University Middletown allowed the CHM 205/625 web-based course the opportunity to undergo its pilot testing phase.

By mid-semester, the CHM 205/625 course enrollment had dropped 50%, leaving the enrollment at five students (3 graduate students and 2 undergraduate students).

While this is certainly a dismal statistic in terms of student retention, Brooks

contends that “attrition rates of 50% are commonplace” in web-based courses and are usually a result of students’ lack of motivation (2). In the CHM 205/625 course, the lack of student motivation could certainly have been a factor influencing the attrition rate, but it was not the only factor. One undergraduate student taking the course as an elective decided early in the semester to undertake some extra service activities, thus prompting her to eliminate any elective courses from her schedule. The events of September 11th forced another student to take a leave from school to travel to New York City. Upon returning, she did not feel it possible to complete the missed work, even with relaxed deadlines. The remainder of the students dropped the course without explanation; a myriad of reasons could be attributed as an explanation, though nothing is certain. What is certain is that these students dropped the course in the first few weeks of the semester, having only completed a few course assignments. Perhaps the expectations set by instructors for the web-based course in terms of workload and responsibility did not match the student expectations. Perhaps the technology was overwhelming. Perhaps another course fit students’ schedules better. Whatever the reason, 50% of the audience was lost over the course of 8 weeks, further reinforcing prior reports of poor student retention so often encountered in web-based courses.

Over the course of the final 8 weeks of the semester, one additional student dropped the course. This particular student, who worked full-time and was taking the course for graduate credit, simply possessed poor self-regulating skills. She missed deadlines and allowed assignments to accumulate to the point of unmanageability.

Near the end of the semester when it became apparent that finishing the work was an unrealistic goal, the student decided to withdraw from the course.

With such a small class size, it is difficult to conduct even pilot analyses and draw meaningful conclusions concerning student learning and satisfaction in the web-based course. Keeping the low student retention rates in mind, a larger audience of individuals was needed for the Spring 2002 course as a basis for exploring the student learning and satisfaction that occurred in the web-based course.

3.3 Technological Issues and the Student

The “Chemistry with TOYS” web-based course requires a basic knowledge of computers and technology. Students in this course are expected to be able to send e-mails, navigate through Internet websites, load and access a CD-ROM, and use Blackboard Courseware. Although most students enrolling in a web-based course should and will have these abilities, it cannot be assumed that every student does. Therefore, in their pre-purchased course materials, students were given specific instructions in regards to accessing and navigating through the course website, loading and accessing a CD-ROM on both Macintosh and PC computers, downloading Quicktime for viewing videos, and using Blackboard and its course management functions. Despite the detailed instructions, I received numerous e-mails and phone calls during the first week of the course from frantic students who had not read the directions provided to them and subsequently found themselves unable to perform one or more the necessary technological functions that the course

demanded. Consequently, the chaos that I had hoped to avoid in getting all students acclimated to the web-based format ensued quickly in the first week of the semester. I spent numerous hours responding to e-mails, reiterating step-by-step procedures dealing with basic computer knowledge. In retrospect, it seems as though the panic and confusion could have easily been avoided had students been given a chance to become familiar with the course's technological components prior to beginning their course assignments, perhaps even with the instructor present as a face-to-face guide.

3.4 Student Performance

In general, the effort exerted by students in the course as well as their overall performance varied considerably over the course of the fall semester. For approximately the first two units of the course, nearly all students were able to keep pace with the assignment deadlines. Overall, their work was good quality. Responses to questions reflected considerable amounts of effort being put forth in doing the hands-on chemistry experiments and thinking critically about the material. However, beginning with the third unit of the course, several students began to fall behind the assignment deadlines due to job commitments and family responsibilities taking precedence over the coursework. Students responded differently to these time constraints. Some students hurriedly completed assignments and answered questions. Their haste was often reflected in the quality of their work, which was often incomplete or incoherent. Other students learned to reserve larger chunks of time on the weekends for completing assignments. This

often meant that they missed deadlines, but the quality of their work did not seem to suffer. This second group of students were genuinely interested in learning from the coursework, rather than in simply rushing to meet a deadline.

It is worth mentioning that the majority of the students in the CHM 205/625 fall course were non-traditional students. Many had full-time or part-time jobs, families, and other responsibilities, which at times, conflicted with their ability to complete the assignments in a timely fashion. In comparison, those traditional students enrolled in the course had a much easier time meeting the assignment deadlines. The quality of their work remained consistent and their frustrations with the course were seemingly less than those students who continually fell behind with the coursework.

3.5 Online Discussion

As part of the course curriculum, students were required to participate in weekly online discussions, facilitated through Blackboard courseware. The weekly discussion question, posted by the course instructor, was intended to coincide with the unit materials that the students are currently covering and should place these chemistry concepts into a real-world context. For example, Unit 3 deals with the topic of density. The discussion question posed asked students to apply concepts concerning density to explain how inflated water wings and inner tubes work to enable people to float with their heads above water.

The discussion board is intended to promote dialogue and conversations among students and instructors. However, during the fall offering of the CHM 205/625 course, the discussion board did not seem to function as intended. First, the same student seemed to post the initial response, while the remaining students tended to just agree with the initial posting rather than expand on the answer or discuss the topic from a different angle. Second, when students began to fall behind in their assignments, the discussion posting no longer coincided with the assignments on which these students were working. Consequently, the discussion question just became another question to answer over the course of the unit rather than a dialogue to be participated in by all.

3.6 Saturday Class Sessions

As part of the distributed learning format, three Saturday class sessions were held over the course of the first semester as a time for students and instructors to meet face-to-face in a laboratory setting. During these class sessions, students were exposed to various hands-on chemistry activities that required laboratory materials or required professional supervision when completing for the first time. In addition, these Saturday sessions served as a time for instructors to revisit activities or concepts of which students did not seem to demonstrate a thorough understanding. Finally, these Saturday sessions served as a time of informal assessment of student learning in the web-based course as well as of the functionality of the web in delivering the course content.

Overall, students responded positively to these Saturday class sessions. Meeting instructors and fellow students added a new level of comfort to the course. Students liked the interactive nature of the classes, whereby they were given the chance to work in groups with their peers in performing activities/demonstrations and answering questions. Given the interactive nature of scientific investigation, some of which mandates a laboratory setting, the distributed learning format for this course proved to be advantageous in ensuring that students received all content that the course was designed to convey while still affording the flexibility of online learning.

3.7 Functionality of the Website for Delivering Course Content

After the initial chaos of acclimating all students to the web-based format of the course, very few additional technical issues arose during the semester to hinder student progress in the course. At the first Saturday class session held mid-September, students expressed no difficulties in navigating through the website to access course materials or to complete assignments. Students felt that the expectations and instructions for progressing through the course were clear and well-defined, leaving little room for ambiguity or frustration on their part.

Over the course of the semester, a technical glitch occurred in which a handful of assignment responses vanished in cyberspace, prompting several students to have to resubmit responses to the assignments. Despite this minor and still unexplained

technical difficulty, students were understanding of the limitations of technology and willingly resubmitted their lost work.

3.8 Proficiency Learning Outcomes

The Ohio Department of Education has established proficiency learning outcomes (PLOs) for students in the subjects of writing, reading, math, citizenship, and science at the 4th, 6th, 9th, and 12th grade levels (22). These learning outcomes describe what tasks or understandings a student at a particular grade level in a given subject should be able to demonstrate. As aforementioned, the primary audience for the CHM 205/625 course is pre-service and in-service elementary and middle school teachers who should possess a working knowledge of these proficiency learning outcomes and how they relate to the content being taught in the classroom. To increase students' familiarity with the science learning outcomes as well as to force them to think about where the CHM 205/625 course assignments fit into their own curricula, a post-test question was assigned in each unit to integrate the state proficiency learning outcomes with the course assignments. Specifically, students were asked to outline the PLOs addressed in each of the unit assignments and to subsequently write one proficiency-style question for each activity.

Despite the good intentions in assigning this question, students became overwhelmed and frustrated with the amount of time and work required to answer such a question. Some units contained up to nine activities, which means outlining PLOs for all the activities and writing a question for each. As instructors, our intent

was not to make this question “monopolize students’ lives”, as one student put it, but simply to help make our audience of potential and practicing teachers more knowledgeable professionals in their field. Students grew increasingly more frustrated with this question, and the quality of their responses deteriorated accordingly. As a result, the “PLO question” in each unit was amended so that students chose one particular activity from a unit, outlined the corresponding PLOs addressed in that activity, and wrote a proficiency style question. In modifying the question, we hoped to decrease students’ frustration with the post-tests in general and to increase the quality of the work put into answering the question, while still providing the necessary exposure to the proficiency learning outcomes established by the state of Ohio.

3.9 Recommendations for Future CHM 205/625 Course Offerings

In light of what was learned during the pilot testing phase of CHM 205/625, several recommendations and modifications were made for subsequent offerings of the “Chemistry with TOYS” web-based course.

3.9a. Audience

Four students completed the Fall 2001 offering of the “Chemistry with TOYS” web-based course. Data was collected from the work of these four students, but a very limited amount given the small sample size. In fact, with such a small sample size, it is nearly impossible to analyze the data and draw meaningful conclusions. Therefore, the audience for the Spring semester course offering needed to be larger than the Fall audience for proper analysis of student learning and satisfaction in the course.

In collaboration with the Miami University’s School of Education, the CHM 205 course was approved as fulfilling a physical science requirement for middle childhood education majors and as a science elective for early childhood education majors. Consequently, undergraduate education majors now had some academic incentive, other than their own personal interest, to enroll in the course.

The aforementioned changes did succeed in increasing the course enrollment for the Spring 2002 semester. Twenty students initially enrolled in the course (13

undergraduates and 7 graduate students) and at the semester's end, seventeen students had successfully completed the course.

3.9b. Technology Issues and the Student

To reduce the number of technology-related problems associated with adjustment to the online delivery of course components, I suggested that future course offerings have a Saturday class session very early in the semester whereby students could learn the basic functions of Blackboard, be introduced to the layout of the course website, become familiar with sending e-mails to instructors and classmates, and practice loading and accessing the Quicktime Videos from the course CD-ROM. In doing so, students are given the chance to explore the basic technological components of the web-based course with the instructor present, become comfortable in navigating through the website, and quench the anxieties that may exist upon beginning an online course. The instructor, in turn, should receive fewer frantic e-mails from students who "cannot login to Blackboard" or who "cannot access the Quicktime movies from the CD-ROM", thus lessening the confusion encountered during the Fall semester.

3.9c. Online Discussion

Overall, the online discussion portion of the course did not succeed in promoting dialogue among students and faculty during the Fall semester. To better facilitate discussion during the Spring 2002 course offering, I suggested that each student be responsible for posting the first response to one online discussion question during the semester. This modification prevents the same student from beginning the

discussion each time a question is posted, as was the case during the fall semester. In addition, I suggested that future instructors emphasize a student's right to pose new, yet related questions during a discussion period in an effort to steer the discussion in a different angle where similar concepts could be discussed. To promote interaction among students, the online discussion needs to indeed become a discussion, a conversation between and among students in the course rather than just another question/answer course component.

3.9d. Proficiency Learning Outcomes

Given the amount of resistance expressed by students during the fall course, my recommendation for future courses concerning the PLO post-test question is to modify according to the fall semester prototype whereby students write PLOs and assessment questions for **one** activity per unit. In doing so, students continue to get exposure to the PLOs and to writing assessment questions, but they do so without the frustration and excessive time constraints encountered during the fall semester when students were responsible for the PLOs and assessment questions for all activities in a given unit.

Chapter 4: Evaluation

The evaluation of the CHM205/625 course involved an analysis of student learning in the course as well as an analysis of students' overall satisfaction with the course and its components. The evaluation instruments and results are summarized in this chapter.

4.1 Analysis of Student Learning

For evaluation purposes, Summer 2001 students enrolled in the traditional face-to-face CHM205/625 were given the same pre- and post-tests that students in the online course completed in the Fall 2001 and Spring 2002 semesters. A comparison of student performance on these pre- and post-tests, namely in Unit 5: Water and Unit 6: Mixtures and Solutions, served as the basis for evaluating student learning in the online course versus the traditional course.

4.1a. Results, Unit 5: Water

An independent samples, two-tailed t-test was used to compare student performance on the Unit 5: Water pre-test. While the students receiving the online instruction scored higher on the pre-test ($M = 3.55$, $SD = 1.43$) than the students receiving the traditional face-to-face instruction ($M = 3.32$, $SD = 1.14$), this difference was not statistically significant, $t(36) = 0.584$, $p > 0.001$, two-tailed. This statistic allows us to infer that both the online and the traditional students had similar background knowledge in the Unit 5 material and were thus starting off “on equal ground” as they began work in Unit 5.

An independent samples, two-tailed t-test was also used to compare student performance on the Unit 5: Water post-test. A comparison of mean scores on the post-test revealed that students in the online course scored higher ($M = 47.05$, $SD = 3.90$) than the students in the traditional face-to-face course ($M = 42.76$, $SD = 3.46$). This difference was statistically significant, $t(40) = 3.94$, $p \leq 0.001$, two-tailed.

4.1b. Results, Unit 6: Mixtures and Solutions

Similar to the Unit 5 analysis, an independent samples, two-tailed t-test was used to compare student performance on the Unit 6: Mixtures and Solutions pre-test. In this unit, students in the traditional face-to-face course scored higher on the pre-test ($M = 3.19$, $SD = 1.13$) than students in the online course ($M = 3.10$, $SD = 1.30$). However, this difference was not found to be statistically significant, $t(40) = -0.27$, $p > 0.001$, two-tailed. Again, it is logical to infer that both the online and the traditional students had similar background knowledge in the Unit 6 material prior to beginning any work in the unit.

An independent samples, two-tailed t-test was also used to compare student performance on the Unit 6: Mixtures and Solutions post-test. Students in the online course scored higher on the Unit 6 post-test ($M = 44.62$, $SD = 1.38$) than students in the traditional face-to-face course ($M = 38.31$, $SD = 1.27$). This difference was found to be statistically significant, $t(43) = 3.37$, $p \leq 0.002$, two-tailed.

4.2 Summary of Student Learning

The statistical analysis conducted on student learning is only a partial analysis as it only includes two of the seven units in the CHM 205/625 course. However, we believe that the trends uncovered in the analysis of these two units are most likely applicable to what would be observed if the other units were to be analyzed.

From the analysis conducted, we can conclude that students in both the online and traditional courses had similar background knowledge about the material prior to beginning any work in the units. While we cannot say with certainty that the online format alone leads to greater student learning, we can say that for this particular sample of students, the online format did not hinder their learning of the material.

4.3 Student Satisfaction with the Course and its Components

In addition to evaluating student learning in the CHM 205/625 online course versus that in the traditional course, we evaluated students' overall satisfaction with the course and its components via a survey. The survey instrument and the results are described in sections 4.3a and 4.3b.

4.3a Survey Instrument

At Miami University, instructors integrating technology into their courses are asked assess their courses using Washington State University's online Flashlight Survey Instrument (23). As one of the instructors for the CHM 205/625 course, I built a survey from a database of validated and verified survey questions formulated by the

Flashlight Program administrators. Students in the CHM 205/625 course completed the Flashlight survey at mid-semester and again at the end of the semester as a means of monitoring their satisfaction with the CHM 205/625 online course and its components as they progressed through the semester.

4.3b Results of Flashlight Survey

Both the mid- and end-of-semester surveys showed high satisfaction with the course and its components. In looking at the mean scores for each questions, students agree or strongly agree with all questions except question 12, which deals with the amount of isolation felt in an online course versus that in a traditional face-to-face course (See Appendix E). Overall, the end of the semester scores on the survey were slightly higher ($M = 50.28$, $SD = 7.87$) than the mid-semester scores ($M = 49.67$, $SD = 6.54$), but this difference was not found to be statistically significant, $t(17) = -0.248$, $p > 0.05$ (See Appendix E).

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APPENDIX A

Learning Objectives for CHM205/625

UNIT 1: MACROSCOPIC VIEW OF MATTER

Students should be able to

1. Provide answers and/or examples for the following questions: *What is chemistry? What are chemicals? What do chemists do? What is the scientific method? How do scientists use the scientific method as a problem solving technique?*
2. Define matter as anything that has mass and takes up space and identify examples of matter based on the definition and sensory observations.
3. Distinguish among the three states of matter based on sensory observations.
4. Distinguish among the three states of matter by comparing and contrasting the physical properties of each state (shape, volume, and compressibility).
5. Draw the three states of matter as they exist at the particle level and specify how the spatial arrangement of the particles in each state accounts for their behavior.

UNIT 2: PHYSICAL EFFECTS OF ENERGY ON MATTER

Students should be able to

1. Explain the properties of matter at the macroscopic and particle level as the temperature and pressure are changed, including changes of state, density, and other observable changes.
2. Observe and explain that for a given, unchanging mass of matter, the volume occupied by that matter in the gas phase is considerably greater than the volume in the solid or liquid state.
3. Explain boiling in terms of intermolecular attractions, temperature, and pressure.
4. Observe and explain how non-thermal energy (light, mechanical, sound, etc.) affect the properties of matter including different types of luminescence (fluorescence, phosphorescence, and triboluminescence), size, pliability, and other similar physical properties.

UNIT 3: DENSITY

Student should be able to

1. Explain that the relative density of two different materials typically accounts for the observation that one material (solid, liquid, or gas) will sink or float in another (solid, liquid, or gas).

[**Exceptions:** Deviation from typical behavior results from factors such as surface tension and buoyancy (in a solid/liquid system) and mixing phenomena (in solid/solid systems.)]

2. Predict the sinking or floating behavior of the different materials, given the relative or absolute densities of the materials, or vice versa.
3. Demonstrate that density is an intensive property of matter (independent of sample size) at a given temperature and pressure.

[To overcome complications with surface tension of liquids affecting the sinking and floating of solids, the solid objects should be placed below the surface of the liquid before it is released.]

4. Demonstrate that the density of a substance depends on both its mass and volume (directly proportional to mass and inversely proportional to volume).
5. Interpret a graph of mass and volume for a given substance and show that the slope of the best fit line is the density of that material.
6. Formulate both conceptual and pictorial understandings of the relative densities of substances in terms of mass and volume of the particles.
7. Apply the concept of density to multicomponent systems to predict and explain observations of sinking and floating.
8. Explain how temperature changes affect the densities of substances.

UNIT 4: PARTICLE NATURE OF MATTER

Students should be able to

Describe the characteristics of atoms, elements, compounds, pure substances and mixtures and be able to distinguish between these at the particle level in terms of composition and energy required to separate them into their component parts.

UNIT 5: WATER

Students should be able to

1. Identify the elements comprising a molecule of water and the ratio of these elements to one another.
2. Formulate a conceptual understanding of why water is a polar molecule and why it behaves similarly to other polar molecules but very different from non-polar molecules.
3. Differentiate between the attractive forces of cohesion and adhesion and apply these to explain the attraction of water to itself and to other substances.
4. Explain the phenomenon of surface tension, recognize situations where it is responsible for a given observation, and describe how/why the addition of surfactants decreases the surface tension of water.
5. Apply the concepts of intermolecular forces and polarity to explain the hydrophobic and hydrophilic behavior of a substance.
6. Recognize and explain the phenomenon of capillary action as it relates to adhesion and cohesion.
7. Explain how cobalt chloride can be used for the detection of water.

UNIT 6: MIXTURES AND SOLUTIONS

Students should be able to

1. Distinguish between homogeneous and heterogeneous mixtures and explain how solutions and suspensions are related to mixtures.
2. Use conceptual models to describe the dissolving process.
3. Describe how solubility is affected by the polarity of the species involved and the role that temperature and pressure play.
4. Develop an understanding of the terminology and concentration units used to describe solution concentration.
5. Select techniques that can be used to separate the components of different homogeneous and heterogeneous mixtures.

UNIT 7: CHEMICAL INTERACTIONS

Students should be able to

1. Give examples of observations that typically indicate the occurrence of a chemical reaction (evolution of a gas, color change, formation of a precipitate, evolution of light energy, temperature change) and also give examples of situations where these same observations are not indicative of a chemical reaction (e.g. boiling, crystallization, shearing).
2. Classify chemical reactions as exothermic or endothermic.
3. Explain how and why temperature affects the rate of a chemical reaction.
4. Use the pH scale to indicate the acidity or basicity of a substance and describe how pH indicators can be used to determine how acidic or basic a solution is.
5. Provide examples of chemical reactions that occur as a result of exposure to light and/or moisture.

APPENDIX B

CHM 205/625 Lessons and
Reference Citations

UNIT 1: MACROSCOPIC VIEW OF MATTER

1. Introduction to Chemistry of TOYS (video)

Lynn Hogue's demonstration of "The Hand is Quicker than the Eye" and "Fortune Telling Fish."

Sarquis, J., Sarquis M., Williams, J. *Teaching Chemistry with TOYS: Activities for Grades K-9*. Terrific Science Press: Middletown, OH; p. 83.

2. Feely Balloons

Sarquis, M. *Exploring Matter with TOYS: Using and Understanding the Senses*. Terrific Science Press: Middletown, OH; p. 59.

3. Identifying Substances by Smell

Sarquis, M. *Exploring Matter with TOYS: Using and Understanding the Senses*. Terrific Science Press: Middletown, OH; p. 135.

4. What is Matter? (Video Activity)

5. Crystal Pictures

Sarquis, J., Sarquis M., Williams, J. *Teaching Chemistry with TOYS: Activities for Grades K-9*. Terrific Science Press: Middletown, OH; p. 19.

6. Properties of Matter

Hogue, L., Sarquis, J., Sarquis, M., Woodward, L. *Investigating Solids, Liquids, and Gases with TOYS: States of Matter and Changes of State*. Terrific Science Press: Middletown, OH; p. 35.

Assessment Activity: Push, Pull...and More

Push, Pull...and More. Instant Science Kit Instruction Manual. Terrific Science Press: Middletown, OH.

7. Particle Nature of Solids, Liquids, and Gases (video)

Ihde, J. University of Madison-Wisconsin.

UNIT 2: PHYSICAL EFFECTS OF ENERGY ON MATTER

1. Moving Molecules

Sarquis, J., Hogue, L., Sarquis, M., Woodward, L. *Investigating Solids, Liquids, and Gases with TOYS: States of Matter and Changes of State*. Terrific Science Press: Middletown, OH; p. 113.

2. Are Mittens Warm?

Sarquis, J., Sarquis, M., Williams, J. *Teaching Chemistry with TOYS: Activities for Grades K-9*. Terrific Science Press: Middletown, OH; p. 67.

3. Temperature Tampering

Teaching Air Pressure with TOYS

4. Egg in a Bottle (video activity)

Sarquis, J., Sarquis, M. *Fun with Chemistry: A Guidebook of K-12 Activities*. Vol. 2, Institute for Chemical Education: Madison, WI; p. 171.

Assessment Activity 1: Enlighten Yourself

Sarquis, M., Hogue, L. *Science Night Family Fun from A to Z*. Terrific Science Press: Middletown, OH; p. 71.

Assessment Activity 2: Air Thermometer

Summer with TOYS: Summer 1997 Air Pressure Activities. Terrific Science Press: Middletown, OH; Activity #103.

5. Shape Shifters

Sarquis, J., Sarquis, M., Williams, J. *Teaching Chemistry with TOYS: Activities for Grades K-9*. Terrific Science Press: Middletown, OH; p. 151.

6. Zap

Sarquis, M., Hogue, L. *Science Night Family Fun from A to Z*. Terrific Science Press: Middletown, OH; p. 301.

7. Hot Summer Days and Those Cool Shades (Part A)

Sarquis, M., Woodward, L. *Science Projects for Holidays Throughout the Year*. Terrific Science Press: Middletown, OH; p. 349.

Assessment Activity: Things that Glow in the Dark

Sarquis, J., Sarquis, M., Williams, J. *Teaching Chemistry with TOYS: Activities for Grades K-9*. Terrific Science Press: Middletown, OH; p. 161.

UNIT 3: DENSITY

1. Sink or Float?

Exploring Density with TOYS: A Resource Module for Elementary and Middle School Teachers. Activity #86.

2. Pouring Air Under Water

Exploring Density with TOYS: A Resource Module for Elementary and Middle School Teachers. Activity #87

Assessment Activity: Density Batons

Sarquis, J.L., Sarquis, A.M., Williams, J.P. *Teaching Chemistry with TOYS.* Terrific Science Press, Middletown, OH; p. 53.

3. Dunked by Density

Exploring Density with TOYS: A Resource Module for Elementary and Middle School Teachers. Activity #95.

4. Household Density Column

Fun with Chemistry, A Guidebook of K-12 Activities; Sarquis, M., Sarquis, J., Eds; Institute of Chemical Education: Madison, WI; 1991; Vol. 1, p. 115.

5. Density Balloons (video activity)

Exploring Density with TOYS: A Resource Module for Elementary and Middle School Teachers. Activity #94

6. The Rainbow Straw

Exploring Density with TOYS: A Resource Module for Elementary and Middle School Teachers. Activity #91.

7. The Cartesian Diver

Exploring Density with TOYS: A Resource Module for Elementary and Middle School Teachers. Activity #100.

Assessment Activity: Disco Raisins

Sarquis, A.M., Hogue, L. *Science Night Family Fun from A to Z.* Terrific Science Press. Middletown, OH; p. 59.

8. That Cold Sinking Feeling (video activity)

Exploring Density with TOYS: A Resource Module for Elementary and Middle School Teachers. Activity #96.

9. Heat It Up!

Exploring Density with TOYS: A Resource Module for Elementary and Middle School Teachers. Activity # 97.

UNIT 4: PARTICLE NATURE OF MATTER

1. **Ping Pong Ball Demonstration (video activity)**
2. **Elements, Compounds, and Mixtures with Paper Clips**

UNIT 5: WATER

1. **Can You Drop (A)Round?**

Water Module: A Resource Module for Elementary and Middle School Teachers.
Activity #163.

Assessment Activity: X-Marks the Spot

Sarquis, A.M., Hogue, L. *Science Night Family Fun from A to Z.* Terrific Science Press: Middletown, OH; p. 227.

2. **Water is Sticky**

Water Module: A Resource Module for Elementary and Middle School Teachers.
Activity #161.

3. **One-Way Screen**

Sarquis, A., Sarquis, J., Williams, J. *Teaching Chemistry with TOYS: Activities for Grades K-9.* Terrific Science Press; Middletown, OH; 1995; p. 177.

4. **Floppy Flatworms**

Sarquis, M., Hogue, L. *Classroom Science from A to Z.* Terrific Science Press: Middletown, OH; p. 71.

5. **Two-tone Flower**

Fun with Chemistry, A Guidebook of K-12 Activities; Sarquis, M., Sarquis, J., Eds; Institute of Chemical Education: Madison, WI; 1991; Vol. 2, p. 9.

6. **Magic Spoons**

Water Module: A Resource Module for Elementary and Middle School Teachers.
Activity #166.

7. **The Hand is Quicker than the Eye**

Just Add Water for Great Science. Terrific Science Kits Instruction Manual. p. 20.

8. **Weather Bunnies**

Sarquis, A., Sarquis, J., Williams, J. *Teaching Chemistry with TOYS: Activities for Grades K-9.* Terrific Science Press; Middletown, OH; 1995; p. 93.

UNIT 6: MIXTURES AND SOLUTIONS

1. Separating a Heterogeneous Mixture

Mixtures and Solutions Module: A Resource Module for Elementary and Middle School Teachers. Activity # 189.

2. Chromatography Color Bursts

Sarquis, J., Sarquis, A.M., Williams, J. *Teaching Chemistry with TOYS.* Terrific Science Press: Middletown, OH; p.195.

3. Crystals Gardens

Sarquis, J., Sarquis, M. *Fun with Chemistry: A Guidebook of K-12 Activities.* Institute for Chemical Education: Madison, WI; Vol. 2, p. 277.

4. Soda pop degassing

Push, Pull...and More. Instant Science Kit Instruction Manual. Terrific Science Press: Middletown, OH; p. 4.

5. The Remarkable Hole-y-ness Nature of Matter

Mixtures and Solutions Module: A Resource Module for Elementary and Middle School Teachers. Activity #180.

6. Quaint Paint

Sarquis, A.M., Hogue, L. *Science Night Family Fun from A to Z.* Terrific Science Press. Middletown, OH; 2000, p. 202.

7. Heat Solution (Video Activity)

Sarquis, J., Sarquis, A.M., Williams, J. *Teaching Chemistry with TOYS.* Terrific Science Press: Middletown, OH, p. 257.

8. Twirly Whirly Milk

Sarquis, J., Sarquis, A., Williams, J. *Teaching Chemistry with TOYS.* Terrific Science Press: Middletown, OH; p. 99.

UNIT 7: CHEMICAL INTERACTIONS

1. Chemistry in a Ziploc Bag

Sarquis, J., Sarquis, M. *Fun with Chemistry: A Guidebook of K-12 Activities from the Institute of Chemical Education*. Institute for Chemical Education: Madison, WI; p. 147.

2. Reactive Colors and Cabbage Patch Detective

Sarquis, M., Hogue, L. *Classroom Science from A to Z*. Terrific Science Press. Middletown, OH; p. 19.

3. Experimenting with Light Sensitive Paper

Sarquis, J., Sarquis, M., Williams, J. *Teaching Chemistry with TOYS*. Terrific Science Press. Middletown, OH; p. 275.

4. Chinese New Year's Poppers

Sarquis, M., Woodward, L. *Science Projects for Holidays Throughout the Year*. Terrific Science Press. Middletown, OH; p. 171.

5. Elements Come to the Point

Sarquis, J., Sarquis, M., Williams, J. *Teaching Science with TOYS*. Activity #34.

6. Investigating the Effect of Temperature on Lightsticks

Sarquis, J., Sarquis, M., Williams, J. *Teaching Chemistry with TOYS*. Terrific Science Press. Middletown, OH; p. 269

APPENDIX C

Microtesting Tasks

Task #1: Go to <http://blackboard.muohio.edu> Login to blackboard and find the CHM 205 course in which you are enrolled.

Task #2: You have found the CHM 205 course on the blackboard website and you want to begin the on-line course. What do you do?

Task #3: You have just completed Introductory On-line Activity #4. Where do you go next to continue working?

Task #4: You want to begin your work in Unit 3: Density. Where do you go to find this unit?

Task #5: Suppose you have found Unit 3: Density and you now want to begin working on this unit. Where do you go to begin your work?

Task #6: Take the pre-test for Unit 3 and check your answers.

Task #7: After completing the pre-test questions and checking your answers, you wish to continue working on this unit. Where do you go next?

Task #8: Find assignment #1 for Unit 3: Density. Complete the assessment question, submit your response, and check your answer.

Task #9: You have forgotten the due date for Assignment #1 in the Density Unit. Where would you go to find this information?

Task #10: You have bookmarked the following URL as a short-cut to the on-line course:

<http://www.terrificscience.org/toysonline>

Suppose you go to this website and would like to begin your work today by completing Assignment #3 in Unit 3: Density. Where would you go?

Task #11: Suppose you want to find out what the on-line discussion questions are for Unit 3: Density. Where would you go to find this information?

Task #12: Suppose you want to submit a response to one of the on-line questions. What would you do?

Task #13: Suppose you have completed all assignments and answered all on-line discussion questions for Unit 3. Where do you go to complete your work for this unit?

Task #14: You are completely finished with Unit 3: Density and you want to continue working on the on-line course. What would you do?

Task #15: It's Monday morning and you want to see if your instructor has posted any important announcements for the week. Where would you go?

Task #16: As you read through Assignment #1 in Unit 4, you find that you do not understand the instructions. What should you do to get clarification?

APPENDIX D

T-Tests of Means for Unit 5: Water and
Unit 6: Mixtures and Solutions

Table D.1 Unit 5: Water - T-test of Means					
	n	Mean	Standard Deviation	t Value	2-Tail Probability
Pre-test					
Online	20	3.55	1.43	0.584	$p \geq 0.001$
Traditional	25	3.32	1.14		
Post-test					
Online	21	47.05	3.90	3.938	$p \leq 0.001$
Traditional	26	42.76	3.46		

Table D.2 Unit 6: Mixtures and Solutions - T-test of Means					
	n	Mean	Standard Deviation	t Value	2-Tail Probability
Pre-test					
Online	21	3.10	1.30	-0.269	$p \geq 0.001$
Traditional	26	3.32	1.13		
Post-test					
Online	21	44.62	6.30	3.37	$p \leq 0.002$
Traditional	26	38.30	6.48		

APPENDIX E

Flashlight Survey Results

Table E.1 Flashlight Survey Results

	High Priority	Priority	Moderate Priority	Low Priority	No Priority	mean	n
1. Encouraging students to take responsibility for their own learning							
Mid	66.7%	27.8%			5.6%	4.50	18
End	77.8%	11.1%	11.1%			4.67	18
2. Building students' confidence in their ability to learn difficult subject matter							
Mid	33.3%	55.6%	11.1%			4.22	18
End	16.7%	44.4%	22.2%	16.7%		3.61	18
3. The academic success of all students in the course							
Mid	22.2%	61.1%	16.7%			4.06	18
End	44.4%	38.9%	5.6%	11.1%		4.17	18
4. Helping all students in the course learn							
Mid	33.3%	61.1%		5.6%		4.22	18
End	50.0%	33.3%		11.1%	5.6%	4.11	18
5. Enabling students to complete tasks at times that are convenient for them							
Mid	50.0%	27.8%	11.1%	11.1%		4.17	18
End	50.0%	16.7%	22.2%		11.1%	3.94	18

	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable	mean	n
6. Assignments for this course were stimulating							
Mid	33.3%	66.7%				3.33	18
End	27.8%	72.2%				3.28	18
7. The instructor for this course gives useful comments on assignments							
Mid	27.8%	61.1%	11.1%			3.17	18
End	5.6%	77.58%	16.7%			2.89	18

	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable	mean	n
8. The instructor for this course is interested in what I have to say							
Mid	44.4%	55.6%				3.44	18
End	50.0%	44.4%			5.6%	3.53	17
9. I feel comfortable telling the instructor when I disagree with something he/she has said							
Mid	27.8%	66.7%			5.6%	3.23	17
End	27.8%	50.0%	11.1%		11.1%	3.19	16
	Much More Likely	Somewhat More Likely	About the Same	Somewhat Less Likely	Much Less Likely	mean	n
10. How likely are you to ask for clarification when you don't understand something							
Mid	11.1%	22.2%	33.3%	16.7%	11.1%	3.06	17
End	5.6%	11.1%	44.4%	27.8%	11.1%	2.72	18
11. How likely are to you feel isolated from other students							
Mid	11.1%	16.7%	38.9%	16.7%	11.1%	3.00	17
End	11.1%	33.3%	27.8%		16.7%	2.75	16
12. How likely are to you feel isolated from the instructor							
Mid	11.1%	22.2%	33.3%	33.3%		2.89	18
End	5.6%	27.8%	33.3%	27.8%	5.6%	3.00	18

	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable	mean	n
15. The technology used in this course did not work in the way that is was supposed to							
Mid		5.6%	38.9%	55.6%		3.50	18
End			61.1%	38.9%		3.39	18
16. The technology used in the course was appropriate for performing the tasks required							
Mid	38.9%	61.1%				3.39	18
End	38.9%	61.1%				3.39	18
17. I would recommend this course to others							
Mid	33.3%	61.1%	5.6%			3.28	18
End	61.1%	33.3%	5.6%			3.56	18
18. I am satisfied with this course							
Mid	38.9%	55.6%	5.6%			3.33	18
End	44.34%	50.0%	5.6%			3.39	18

Table E.2 T-Test of Means for Flashlight Survey

	n	Mean	Standard Deviation	t Value	2-Tail Probability
Mid-semester	18	49.67	6.54	-0.248	p ≥ 0.001
End-of-semester	18	50.28	7.87		
