The Effects of Clickers and Online Homework on Students' Achievement in General Chemistry

By

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ABSTRACT

Retention of an introductory general chemistry course material is vital for student success in future chemistry and chemistry-related courses. This study investigated the effects of clickers versus online homework on students' long-term content retention, examined the effectiveness of online homework versus no graded homework on students' achievement in a first-semester general chemistry course, and assessed students' attitudes toward the use of online homework. Students' data from the yearlong American Chemical Society General Chemistry (ACS GC97) exam, teacher-prepared final exams, and online surveys were analyzed to measure the effects of clickers and online homework on students' long-term content retention and performance, and to capture students' attitudes. A variety of methods including Welch ANOVA, independent samples *t*-test (Welch), Pearson's correlation, test of proportions, and Pearson's Chi-square test were used to analyze the data. The analyses indicated that the use of clickers or online homework did not significantly improve students' long-term content retention of general chemistry course material, that the use of online homework was more beneficial than, or at least as effective as no graded homework in improving students' performance, and students valued the fact that online homework provided immediate feedback. Additionally, results of this study revealed that greater numbers of students were retained in clicker and online homework classes than non-clicker, non-online homework classes and that various types of online homework systems used in general chemistry could impact student performance differently. Implications of the findings and future research directions were presented.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER ONE: INTRODUCTION

Purpose of the Study

The purposes of this study were: i) to investigate the effectiveness of student response systems (clickers) on students' long-term general chemistry I content retention, as compared to teaching methods facilitated by online homework or lecture-only (non-clicker, non-online homework) approaches; ii) to examine the effect of online homework on students' achievement in a first-semester general chemistry course by comparing their performance on teacher-prepared final exam common questions for students using online homework and for students not using online homework; and iii) to investigate students' attitudes toward using online homework in first- and second-semester general chemistry courses.

Significance of the Study

Because of the perceived benefits, along with promising research findings, of clickers and online homework systems, it is the belief of the researcher that the use of clickers and online homework would continue more extensively in the future at various levels of educational institutions. Therefore, this study is of special significance because it would determine the long-term effects of clickers and online homework systems on student learning. The study would also determine whether the use of online homework systems help to improve students' achievement in general chemistry I course and how students' attitudes toward the use of online homework are correlated with their characteristics.

Additionally, while there are a number of studies on the effect of clickers or online homework on student performance/short-term learning, there is a lack of research regarding the effects of clickers versus online homework on students' long-term content retention of general chemistry course material. To the researcher's awareness, there is no study that directly addressed this issue. Hence, the result of this study would fill a gap in literature concerning the effect of clickers and online homework on long-term learning, add to the growing body of literature on clickers or online homework, and may set stage for further studies on the effect of clickers versus online homework on students' long-term learning in upper-division chemistry and other non-chemistry courses. More specifically, this study would provide instructors and educational decision makers with new and useful information regarding the effect of clickers and online homework systems on students' long-term content retention of General Chemistry I course.

Organization of Dissertation

This dissertation is organized into six chapters: the first chapter includes a description of the purpose of the study, significance of the study and a literature review regarding online homework and clickers, the second through fourth chapters include the results of my studies on the effects of clickers versus online homework on students' long-term content retention, online homework versus no graded homework on students' achievement in general chemistry course I material, and students' attitudes toward online homework. The fifth chapter contains results of aqueous syntheses of some Group 1 Metal TRISPHAT salts. Following my studies is chapter six, which includes general conclusions; summary of this work, implications and suggested future research directions.

Summary of Research

The first study of this dissertation investigated the effects of clickers versus online homework on students' long-term retention of general chemistry I course material. Long-term content retention was measured by a comprehensive yearlong American Chemical Society (ACS) GC97 exam administered seven months after students had completed general chemistry I course. Neither clicker nor online homework systems significantly improved students' long-term content retention of general chemistry I course material. However, more students were retained both in clicker and online homework classes than lecture-only classes.

The second study examined the effect of online homework versus no graded or no online homework on students' achievement in general chemistry I course. This study used teacher-written exams to measure students' performance in general chemistry since the standardized ACS exam used in the first study washed away any significant difference that could be present between the experimental and control groups. Students using online homework for general chemistry I course performed significantly better on the final exam common questions than students using no graded homework when similar instructors were involved in teaching the course in the same semester. Although students using Online Web Learning (OWL) outperformed students using WebAssign online homework, no significant difference was found between the online homework (WebAssign or OWL) students and no online homework students on their exam performance when a single instructor taught the course all the groups over several semesters.

The third study investigated students' attitudes toward the use of online homework in general chemistry courses in an effort to determine whether students' characteristics were correlated with the perceived benefits of online homework. This qualitative piece of study complements the second quantitative study on online homework since students' attitudes toward online homework are as crucial to its success as any other variable. Students' responses to the online survey indicated that students valued the fact that online homework system provided immediate feedback. Students' gender and their self-reported GPA were significantly associated with one of the perceived benefits of online homework whereas their age and classification in school were not correlated with any of the perceived benefits.

Literature Review on Online Homework and Clickers

This section describes the literature review regarding online homework (definition of homework, online homework, and research related to online homework) and clickers (description of clickers and research related to clickers).

Homework

Homework can be defined as "tasks assigned to students by school teachers that are meant to be carried out during 'noninstructional' time".[1-2] This definition excludes: (a) in-school or out-of-school guided study or tutoring; (b) home study courses; and (c) extracurricular activities. The instructional purposes of homework, as LaConte[3] described, include providing students with an opportunity to: i) practice new skills and concepts recently presented in class; ii) prepare on topic prior to introduction of new material; iii) extend newly acquired skills to other situations; and iv) integrate separately learned skills

and concepts to produce a single product.[4-5] While achieving these instructional purposes by assigning paper-based homework seems feasible in small classes, achieving the instructional purposes of homework, particularly in large classes has become a great challenge since grading a large number of paper-based homework assignments and providing students with immediate and detailed feedback does not seem viable. As a result, many instructors have adopted online homework systems as a substitute to the traditional paper-based homework in an effort to cope with the challenges, improve student learning, and, at the same time, take advantages of computer's capability of grading a large number of homework assignments and providing feedback instantly to students.

Online Homework

Online homework system is a service which can be accessed from any standard browser and internet connection. The system delivers assignments to students, grades their work instantly, and keeps a permanent record of student scores.[6] There are various types of online homework systems implemented in the teaching-learning process of different courses at different levels. The online homework systems that have been commonly used in teaching General Chemistry courses include: Online Web-Based Learning (OWL), WebAssign, Assessment, Review, and Instruction System (ARIS), WileyPLUS with CATALYST, Mastering Chemistry, and SmartWork. This study, specifically employed OWL and WebAsssign online homework systems, of which overviews of some of their features are presented below.

OWL incorporates a variety of questions that include concept oriented, calculation based, or particulate views of reactions or processes, and contains tutorials, chemical simulations, videos, and additional practice exercises. OWL provides instant feedback regardless of the correctness of the answers and keeps a record of students' homework scores and time each student spent on homework. OWL can also be used as an alternative method to give online exams. However, OWL is linked to specific textbooks, and is incompatible with some course management systems.[7] WebAssign provides immediate feedback and helps students discuss about homework problems with their instructor using message boards. This system enables both instructors and students to see grades in a timely manner on grade book. WebAssign, unlike OWL, is not tied to specific textbooks and can be used with more than 400 textbooks.[8]

Research Related to Online Homework

The literature regarding online homework has focused on: developing online homework system; examining the effect of online homework versus no graded homework or traditional paper-based homework on student performance; or exploring students' attitudes or perceptions about online homework.

Articles on Developing Online Homework System. Spain[9] developed computer-interactive problem sets for general chemistry where students were provided with personalized problem sets on disk. Students were required to complete assignments on computer and submit their graded report as electronic version or printed record. The system provided immediate feedback to students and had most features that online

homework system has, but was not supported with web. Hall *et al.*[10] developed web-based homework assignments for general chemistry and examined the effect of allowing for multiple attempts (two times) on students' performance. The result indicated that providing students a second-chance to work on homework assignments helped students actively involved in problem solving and, at the same time, improved their course grades. The study also revealed that students had positive attitudes toward using online homework with the second-chance option.

Freasier, Collins, and Newitt[11] developed web-based interactive homework quiz-tutorial system by modifying WWWAssign homework system to promote long-term willingness among students to practice answering problems that involve conceptual understandings in chemistry. Their survey results showed that students did more homework quizzes than required for the course, and a vast majority of students reported that the web-based homework assignments were helpful learning tools. Chamala *et al.*[12] developed an electronic program for organic chemistry homework (EPOCH) and surveyed students' perceptions about the effectiveness of the program. EPOCH enabled students to draw structures electronically as answers to homework assignments, provided immediate feedback to students' responses and elucidated why their work was correct or incorrect, but did not directly disclose the correct answer. The survey results in this study indicated that students believed that EPOCH improved their performance on exams.

Online Homework versus no Graded Homework or Traditional Paper-Based Homework on Students' Performance. Studies comparing the effect of online homework versus no graded homework or traditional paper-based homework found mixed results.

Allain and Williams[13] compared the use of online homework to the use of no graded homework in an introductory astronomy course and found no significant differences in students' conceptual understanding or test scores. Jacobson[14] examined the effectiveness of computer homework assignments on student learning in pre-algebra course in comparison to non-computer homework assignments, finding no significant difference between those who did computer homework or traditional non-computer homework assignments. Zerr[15] described that the use of online homework system improved student learning in first semester calculus. The quantitative analysis of Zerr's study[15] showed that students who used the online homework system obtained better grades in homework assignments than those who used no online homework. Dillard-Eggers *et al.*[16] found that online homework increased students' performance in college accounting principles classes.

Cole and Todd[17] compared performance of students who did online homework assignments to those who completed paper-based homework assignments from textbook in general chemistry course, finding no statistically significant difference between the online and traditional paper-based homework students. El-Labban[18] compared the performance of general chemistry students who used online homework to those who did traditional paper-based homework on American Chemical Society (ACS) final exam, finding that there was no statistically significant difference between the two groups. Results from this study also indicated that students' attitudes toward online homework were not correlated to ACS final exam scores.

Arasasingham, *et al.*[19] indicated that i) students who used online homework system significantly outperformed those who used traditional paper-based homework; ii) students' average homework scores were significantly correlated with the scores on the final examination for both online homework and traditional paper-based homework students; and iii) that the online homework students performed significantly better than traditional paper-based homework students in conceptual question, but found no significant difference between the two groups on their performance in an algorithmic question. Frnewever[20] compared the effectiveness of web-based versus paper-based homework on student learning in general chemistry course. The result from this study also indicated that online homework was as effective as paper-based homework for student learning.

Kodippili and Senaratne[21] demonstrated that using computer-generated interactive mathematics homework improved students' mathematics course final grades (A, B, or C) when compared to using traditional paper-based homework. Palocsay and Stevens[22] compared the effectiveness of three web-based homework systems (ALEKS, PH Grade Assist, and custom-made online quizzes in Blackboard) versus traditional paper-based homework assignments in teaching undergraduate business statistics courses. The results indicated that the type of homework system made little difference on students' course performance, especially when the effects of teacher experience and student academic competence were controlled.

Burch and Kuo[23] compared the effect of online homework versus traditional paper-based homework on students' performance of 4 college algebra exams, and found

that online homework students scored significantly higher on the first three exams (except the final exam) than paper-based homework students. The study also revealed that retention rate of students for online homework sections was higher than that of traditional paper-based homework sections. Arasasingham, Martorell, and McIntire[24] demonstrated that using online homework improved students' performance on general chemistry final exams regardless of students' level of preparation and over multiple classes, multiple instructors and multiple years.

Student Attitudes or Perceptions about Online Homework. Studies exploring students' attitudes toward online homework indicated that students either had positive attitudes toward using online homework[12,24-26] or perceived online homework as effective as paper-based homework to prepare for tests.[21] Demirci[27] analyzed students' perceptions about web-based versus paper-based homework in a general physics course and found that students had positive perceptions about web-based homework. Demirci's study[27] also showed that online homework students performed significantly better on homework assignments than paper-based homework students. However, there was no a statistically significant difference in on physics final grade scores between the assigned groups.

Smolira[28] conducted a questionnaire to assess students' perceptions of online homework in an introductory undergraduate and a prerequisite MBA graduate finance classes. In this questionnaire, students reported that i) they preferred online homework to paper-based homework, ii) they felt that online homework helped them understand the material and increased the time they spent in preparing for the class. The result revealed that MBA graduate students had a higher degree of satisfaction with the online

homework than did undergraduate students. Jones[29] surveyed students' perceptions about the impact of web-based homework on course interaction and student learning in an introductory accounting course. Results from this survey showed that students believed that web-based homework systems improved their learning, but did not increase their interaction with the instructor in the course. Students also reported that the systems' capability of allowing for multiple attempts and providing immediate feedback encouraged them to practice with the material.

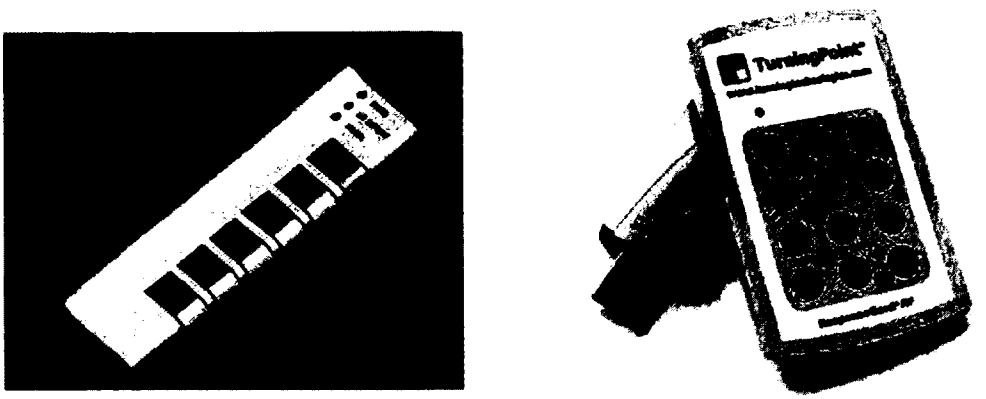
Hodge[30] surveyed students' motivation and perceptions about learning on using web-based homework in college algebra course. The survey results indicated that students were highly motivated to complete more web-based homework assignments than traditional paper-based assignments, but students highly differed in their perceptions about web-based homework. Richards-Babb, *et al.*[26] investigated students' perceptions about online homework and the effect of online homework on students' performance and success rate in general chemistry. The analysis indicated that students had positive perception about online homework, would recommend online homework for future classes, and completed higher percentage of online homework assignments.

In summary, this review of literature on online homework indicated that online homework was more beneficial than, or at least as effective as, traditional paper-based homework and that students had either positive or neutral attitudes toward using online homework. More importantly, the review of literature revealed that there was a lack of research on the effect of online homework on students' long-term content retention of general chemistry I course material.

Clickers

Clickers (Student Response Systems, SRSs) are small handheld devices used by students to remotely and anonymously respond to instructor's questions asked inside classroom[31] Students' responses are usually displayed in the form of histogram to an entire class, and whenever there is much variation in students' answers, it is up to the instructor to decide whether that topic is worth reviewing before moving on to the next topic or allowing extra minutes for students to discuss the topic with their peers and revote individually to see if a consensus has been reached. There are various types of clickers such as TurningPoint clickers, i-clickers (Figure 1.1.), or systems including applications that can be used on the web or with cell phones.[32] TurningPoint clicker was a brand that has been used in this study. Clickers use either infrared (IR) or radio frequency (RF) transmitters or signals.[33] However, RF clickers have been widely accepted because RF clickers, unlike IR clickers, use USB device, require no line of sight from the student to a receiver, experience no interference with the classroom light and other IR sources, and support a large number of clickers with a single receiver.[33]

Clickers have been used inside classroom to hold students' attention by making classes more interactive,[34] create a better learning environment,[35] improve student participation, or engagement in class.[36-38] Clickers can also be used to create awareness and address students' misconceptions of a specific topic,[39] or identify most confusing or least understood topic (muddiest point) from each day's lecture.[40]



a) b)

Figure 1.1. Types of Clicker: a) i-clicker[41] and b) TurningPoint clicker[42]

Research Related to Clickers

Literature concerning clickers emphasized on the following issues: discussions of adoption or practical use of clickers; reviews of research articles on clickers; investigation of effect of clickers on students' performance; comparisons of effectiveness of clickers to non-clicker technologies or other active learning strategies; or exploration of students' perceptions about clickers.

Articles Discussing Adoption or Practical Uses of Clickers. A number of articles on clickers focused on adopting clickers in classrooms or discussing activities/tasks that could be done in large classrooms to effectively use clickers. Woelk[43] provided taxonomy of tasks and activities that can be done to improve student engagement when using clickers in large classes. The taxonomy of clicker activities had two major categories: i) 'I am" category ("I am here", "I am prepared", and "I am interested") where instructors

check students' attendance, preparedness, and develop their students' interest in the subject; and ii) "I do" category ("I learn", I understand", and "I apply") where instructors assess whether students learn what was introduced in class, comprehend the course material, and make meaningful connections. Towns[44] revised the "Technology adoption life cycle" model, which discusses how a new technology penetrates the progress of consumers, to illustrate the adoption of clickers by faculty. This study described that faculty, as consumers of new technologies like clickers, can be grouped as innovators (technology enthusiasts), early adopters (visionaries), early majority (pragmatists), late majority (conservatives), or laggards (skeptics).

Lanz[45] discussed effective methods of using clickers and identified the following as possible effects of clickers: i) active learning and generation effect, ii) attention, iii) attendance and class preparation, iv) immediate feedback, v) feedback for instructors, and vi) depth of processing. Solecki, *et al.*[46] demonstrated that clickers were easy, reliable, enjoyable and engaging tools for learning and gathering research data in a nursing education conference. Moss and Crowley[47] also illustrated that clickers could be used for evaluating events and collecting information for research purpose in addition to testing students' understanding of concepts in a specific course.

Articles Reviewing Research on Clicker. Some of the articles on clickers were targeted at reviewing the existing literatures.[33,48-49] Caldwell's review[33] of literature on the applications of clickers in large classroom in different fields indicated that using clickers in large classroom had either neutral or positive effect on students' performance on exams, and that the positive effect of clickers on students' performance were more

enhanced when clickers were used with peer instruction or other cooperative learning methods. MacArthur and Jones[49] reviewed research articles on clickers and identified that clickers were mostly used as a formative assessment tool and a means to foster student collaboration. They also pointed out that the need for student adjustment, time limitations, and technology issues were the common drawbacks of using clickers in classrooms.

Effect of Clickers on Students' Performance. A majority of articles on clickers focused on examining the effects of clickers on students' performance and found mixed results. Some studies showed that the use of clickers improved students' performance[50-54] while others found that clickers made no difference on students' performance.[55] Students' long-term retention of introductory biology course was enhanced as a result of using clickers in classrooms.[50] However, not all the studies found the positive effect of clickers on improving students' long-term retention.[50,55]

Comparisons of Clickers with Non-Clicker Technologies or other Active Learning Strategies. Some of the articles on clickers also compared the effectiveness of clickers versus non-clicker technologies or other active learning strategies. These studies indicated that clickers were more effective than group questioning method[56] or paper-based unexpected quizzes,[57] as effective as group discussion method[58], and less effective than online quiz assessment[59] in improving students' performance on course exams.

Student Perceptions about Clickers. Wolter, *et al.*[60] surveyed students' perceptions about using clickers in an introductory biology classes in nine institutions in United States and Canada, finding that female students had more positive attitudes

toward using clickers than male students. The results also indicated that non-science major students had more positive perceptions about using clickers than science major students. Studies showed that students had positive perception about using clickers in nursing education classes,[61-62] in upper-division physics courses,[63-64] and in psychology class.[65]

In general, the literature review on clickers showed that the use of clickers had either positive or neutral effect on student learning, and that students had positive or neutral perceptions about the use of clickers. This review also revealed that there was no study that directly addressed the effect of clickers on students' long-term content retention of general chemistry I course material. Therefore, the presence of a gap in literature, particularly on the effect of clickers or online homework on students' long-term content retention of general chemistry I course material was one of the driving forces to conduct a study on the effect of clickers versus online homework on students' long-term content retention of general chemistry I course, which was presented in chapter two. Additionally, the inconsistency of research results on the effect of online homework on students' achievement and on students' attitudes toward the use of online homework prompted us to perform studies presented in chapter three and four, respectively.

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CHAPTER TWO: EFFECT OF CLICKERS *VERSUS* ONLINE HOMEWORK ON STUDENTS' LONG-TERM RETENTION OF GENERAL CHEMISTRY COURSE MATERIAL

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Abstract

This study reports the effects of Student Response Systems (clickers) versus online homework on students' long-term retention of General Chemistry I course material. Long-term content retention was measured by a comprehensive yearlong American Chemical Society (ACS) GC97 exam administered seven months after students had completed General Chemistry I course. The analysis indicated that while students who used clickers or online homework systems earned a little over 2 % higher than non-clicker, non-online homework (lecture-only) group on ACS GC97 exam average scores, this difference was not statistically significant. Interestingly, the data also revealed that more students were retained both in clicker and online homework classes than lecture-only classes. This work suggests that treatments that enhance student's feedback may increase student retention in the course sequence with no loss in learning.

Introduction

Retention of introductory general chemistry course material is vital for student success in future chemistry and chemistry-related courses. However, in many cases, the learning environment in general chemistry classes does not seem to promote student

long-term retention of material. One of the major roadblocks to the use of optimal learning environment in general chemistry courses is that they are usually taught as large classes. Unfortunately large classes are usually associated with less than favorable outcomes, including increased faculty reliance on the traditional lecture method, less active student involvement in the learning process, fewer instructor-student and student-student interactions, and reduced frequency of or no graded homework assignments, resulting in less feedback to students.[1-4] This is precisely the situation facing many professors as the number of students enrolled continues to increase out pacing the hiring of new faculty.

In order to minimize the undesired results associated with teaching large classes, and more importantly, to increase student long-term (beyond the end of the course) retention of course material in large classes, instructors have adopted a variety of teaching strategies inside and outside of the classroom. One of the promising strategies that can enhance student learning and retention of information is the integration of emerging technologies into instruction. Among the technologies that have been extensively used in many institutions of higher education are Student Response Systems (Clickers), which require students to answer questions in class like ConcepTests,[5-11] and online homework (OHW) systems, which require students to answer questions outside of the classroom.[12-16] Although clickers and online homework are used in different contexts, both have been praised for engaging students in learning activities and providing immediate feedback that can assist in student learning.[2,13,17-21]

Studies examining the effect of clickers in chemistry found some promising results. King and Josh[22] found that using clickers in a large general chemistry lecture class at the university level enhanced student performance on exam questions that were related to content taught with clickers and considerably improved female students' class participation. An ethnographic study designed by Hoekstra[3] suggested that the use of clickers in a large general chemistry lecture class at the university level improved student engagement, enhanced peer discussions among students, facilitated effective problem-based learning, and increased students' comfort level when working together.

Sevian and Robinson[23] demonstrated that clickers could be used effectively in both small and large undergraduate level General Chemistry lecture courses, in a small graduate-level class for environmental toxicology, and in undergraduate environmental science laboratory classes. Their study indicated that clickers were effective in promoting learning in the sciences, especially when the use of clickers was "transparently integrated with the content", and maintained the "flow of the class" without diverting students' attention from the lesson.

Bunce *et al.*[17] compared the effect of clickers versus online quiz assessment on students' performance in a medium sized (N = 41) lecture class of a general, organic, and biochemistry course for nursing students in a small private university. The results indicated that using online quizzes significantly improved students' performance on teacher-written exams, but clickers did not. Neither clickers nor online quizzes significantly improved students' performance on the organic and biochemistry subsections of the ACS General, Organic, and Biochemistry exam Form 2000.

Research has also been done on the impact of clickers in other disciplines including biology, pharmacy, psychology, and computer science. Studies on the effect of clickers on student learning,[24-28] students' long-term retention of course material,[24-25,27] and the differential effects of clickers versus other classroom techniques such as the class discussion method,[29] the group questioning method,[30] and paper-based unexpected quizzes.[31] Most of these studies found statistically significant differences in student performance, favoring clickers.[24-28,30-31]

However, the results on long-term retention of information are inconsistent. Lui *et al*[27] found no statistically significant difference on long-term (one month) retention of pharmacy course material between students taught with clickers or without clickers. Doucet *et al.*[25] indicated that using clickers in veterinary clinical pharmacology course did not significantly enhance students' long-term (twelve month) content retention.

Crossgrove and Curran[24] investigated students' long-term retention of course material as measured by tests administered four months after they had completed the course for an introductory biology course for non-majors and a genetics course for biology majors. Results from this study indicated that using clickers in the introductory non-major biology class significantly improved students' long-term retention of material that was related to clicker-based questions, but using clickers in the biology major genetics class made no difference on students' long-term retention. The authors noted that the clicker questions in the genetics course were application or comprehension questions whereas the non-clicker questions were knowledge or comprehension questions, and the level of feedback provided to the genetic students was not same as that provided

in the non-major course. The study suggests that students perform better when exam questions are on material covered using clickers, and that level of feedback given to students after answering clicker questions is vital for enhancing students' performance on exams.

Studies that compared the effect of clickers to other active learning strategies also found mixed results. For instance, Martyn[29] found no statistically significant difference on students' performance on introductory computer information systems exams when clickers or the class discussion method were used during lectures. Mayer *et al.*[30] investigated the effect of clickers on student performance in comparison to the group questioning method, finding significantly better student performance on educational psychology exams for students taught with clickers than for students taught with the group questioning method. Shapiro[31] showed that students who used clickers outperformed students who used either paper-based unexpected quizzes or paper-based extra credit opportunities, especially on test questions that were similar to clicker's questions. In summary, the findings from recently published studies on the effect of clickers on student learning did not agree as to whether clickers had a positive or negative influence on student learning or long-term content retention.

Studies investigating the effect of online homework on students' performance in chemistry and non-chemistry courses found inconclusive results as well. In some cases, online homework assignments improved students' performance in course exams significantly better than paper-based homework assignments,[32-34] and in others, online

homework assignments were found to be as effective as paper-based homework assignments.[13,35-38]

While clickers or online homework have been studied in a variety of settings, none of the studies reviewed directly investigated the effect of clickers on student long-term retention of General Chemistry material, particularly in comparison to online homework. This study hypothesizes that the benefits of clickers and online homework – engaging students in learning activities and providing immediate feedback to students - would be followed by an improvement of student long-term retention of information.

Theoretical Framework

The constructivist perspective asserts that learning is a process of knowledge construction rather than knowledge recording or absorption.[39] In other words, knowledge is actively constructed by the learner based on prior knowledge rather than being transferred directly from the mind of the teachers.[40] Therefore, students need to interact with their teacher and peers in classroom instruction, and should actively participate in a system of practices to develop conscious awareness of and mastery of subject-matter concepts.[40] We applied this perspective for this study because we assume that using clickers or online homework, through engaging students in learning activities and providing them with immediate feedback, can help students actively interpret and impose meaning through their existing knowledge structures.[39] As a result, we expect students to have deeper understanding or better construction of knowledge that can be reflected in their long-term content retention of the course material.

The purpose of this study was to investigate the effectiveness of clickers on students' long-term General Chemistry I content retention, as compared to teaching methods facilitated by online homework or lecture-only (non-clicker, non-online homework) approaches. The findings from this study would fill a gap in the literature concerning the effect of clickers versus OHW on long-term learning.

Method

Participants

The subjects in this study were 160 undergraduate students at a regional comprehensive University who took the yearlong ACS GC97 final exam in a general chemistry II (GC II) course in Falls 2008, 2009, or 2010, after having taken the general chemistry I (GC I) course during the previous spring semester. Students taking GC II in the summer were excluded from this study since the ACS standardized exam (the data collection instrument) was not used consistently during the summer. This study used data from the Spring General Chemistry I and Fall General Chemistry II semesters because clickers were only used in General Chemistry I during the Spring semesters. The professor implementing clickers in GC I had other assignments in the Fall semesters.

Material and Instruments

Clickers. TurningPoint clickers (with receiver and software) were used in selected general chemistry I classrooms to engage students in active learning during the Spring 2008, 2009, and 2010 semesters. The same professor taught all of the general chemistry I classes that used clickers. After a trial run in 2008, each class session contained 4-6

multiple-choice clicker questions. The professor who taught the clicker classes regularly assigned ungraded problems from the textbook to help students prepare for the clicker questions. Based on students' self-reported data collected by clicker votes, only about half of these students did the ungraded textbook assignments. This study included all students in the clicker classes regardless of whether they did the textbook assignments or not.

Online Homework. The classes in this study used two different types of online homework systems (WebAssign or OWL) to help general chemistry I students gain practice with the course material outside the classroom. WebAssign was used in Spring 2008 and Spring 2009, and OWL was used in Spring 2010. This change was based on a departmental decision to adopt a new textbook supported by a different online homework system. A single professor, different from the one who taught the classes that used clickers, taught all of the general chemistry I classes that used online homework assignments, while several other professors used neither clickers nor online homework assignments in General Chemistry I classes.

American Chemical Society (Yearlong) General Chemistry Exam (GC97). The GC97 exam was designed and validated by the ACS Institute and endorsed by ACS as an appropriate means of assessing students' knowledge of chemistry. The general chemistry courses in this study used the GC97 as a common final exam for all students. The GC97 exam consisted of 70 multiple-choice items, which were divided into 40 questions related to the material discussed in general chemistry I (GC I subset) and 30 questions related to the material covered in general chemistry II (GC II subset) by the Coordinator of General

Chemistry. This categorization was evaluated and accepted by the general chemistry faculty participating in the study. The 40 GC I subset questions from the ACS exam were used to measure students' long-term retention of general chemistry I material since it would have been seven months since these students completed the GC I course.

Research Design

In this study, a quasi-experimental design[41] was used to compare the GC I subset scores from the ACS GC97 exam for students in the clicker group, the online homework group, and lecture-only group. The study used the types of learning activities completed by students (online homework outside of classroom, the use of clickers in the classroom, or neither of these) as the independent variable and ACS GC I subset score as the dependent variable. The classification of the participants into experimental and control groups of GC I instructional method is presented in Figure 2.1. At the end of the General Chemistry II course, all of the participants completed a common ACS institute final exam in order to measure their long-term retention of General Chemistry I course material. Thus our definition of "long-term" is "7-10 months after introducing the concept". The data from the ACS GC97 exam were retrieved with the approval of the university IRB committee and in consultation with the coordinator of the general chemistry courses. The yearlong ACS exam answer sheets were machine scored and the percentage of correct responses for the GC I were determined for each student.

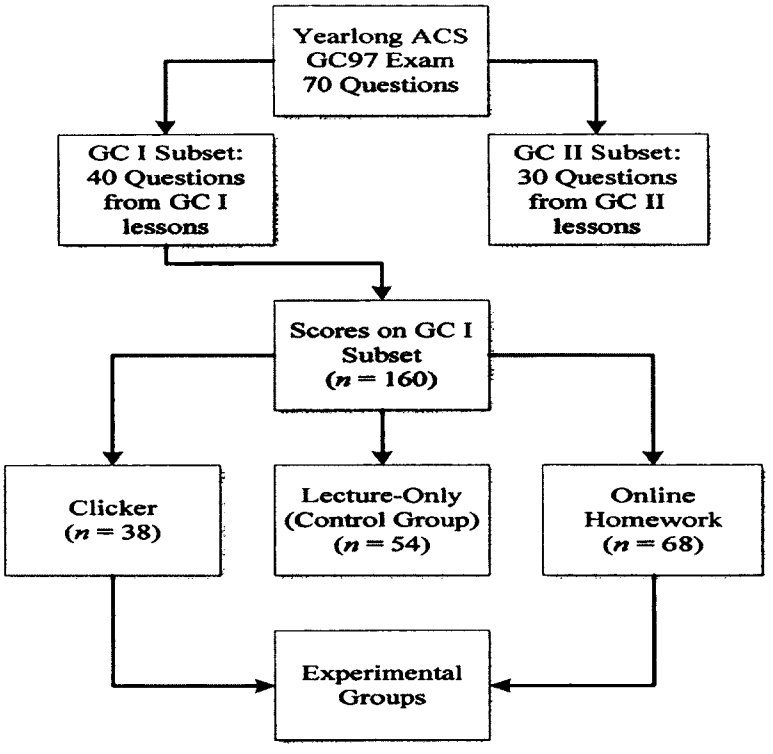

Figure 2.1. Classification of the participants into experimental and control groups based on GC I instructional method

Statistical Analyses

Welch analysis of variance (Welch ANOVA) is traditionally used when the experimental and control group sizes are different, as was the case in this study. The Welch ANOVA was used to compare the scores in the GC I subset of the ACS GC97 exam for the three groups on students' long-term retention of general chemistry course materials. All the statistical analyses were performed using Predictive Analytics Software (PASW) Statistics version 18.[42]

Results and Discussion

In order to investigate the effectiveness of clickers and online homework on students' long-term content retention in general chemistry I, the average scores for students from the 40 GC I subset of questions (used as percentages) were compared for the students in the clicker group, the online homework group, and the lecture-only group (non-clicker, non-online homework). Descriptive statistics for ACS GC I subset scores for these groups appear in Table 2.1.

Table 2.1. Descriptive Statistics for GC I subset for ACS Common Final Exam Scores*

Group	*N*	$\bar{x}$ *(%)*	*SD*
Experimental group (s)			
Online homework	68	49.82	14.81
Clickers	38	50.33	14.30
Control group			
Lecture-only	54	47.69	14.73

* The GC subset scores in the ACS exam used in this study are based on the 40 GC I questions and are presented as in percent. Comparison with the National Average Score for ACS GC97 form was not possible since the National Average score is based on all 70 questions on the GC97 exam.

The average scores indicate both the clicker ($\bar{x}$ = 50.33, *SD* = 14.30) and online homework ($\bar{x}$ = 49.82, *SD* = 14.81) students earned scores a little over 2 % higher than lecture-only ($\bar{x}$ = 47.69, *SD* = 14.73) students.

The Welch ANOVA indicated that there was not a statistically significant difference (at the $\alpha = 0.05$ level) among the three instructional methods (clicker, online homework, lecture-only), *Welch's F* (2, 93) = 0.461, $p = 0.632$, in improving students' long-term retention of the General Chemistry I course material. This finding indicated that the additional use of clickers in the classroom or online homework outside classroom in this regional comprehensive University did not significantly improve students' long-term retention of material in the General Chemistry I course.

Interestingly, a greater number of students finished the General Chemistry sequence in the following Fall semester in the classes where clickers or online homework were used in General Chemistry I when compared to the lecture-only General Chemistry I classes (Table 2.2).

Table 2.2. Number of students who enrolled for GC II and took the ACS GC97 exam in the following fall semester after they had taken GC I in the spring semesters of 2008, 2009, & 2010

Groups	Enrollees in Spring (2008, 2009, 2010)	Enrollees in Fall (2008, 2009, 2010)	Retention rate (%)
Online homework	290	68	23.4
Clicker	153	38	24.8
Lecture-only	395	54	13.7
Total	838	160	19.1

Anecdotal evidences and a quick survey administered using clickers in clicker classrooms indicated that using clickers for the General Chemistry I course increased student attendance (more than 90% attended the clicker classes). The survey result also showed that a vast majority of the students in the clicker group felt that clickers should be used more broadly in other courses university-wide. Unfortunately, this study did not compare student attendance among the three groups since the instructors who taught online homework and lecture-only classes did not record students' attendance in their classes on a regular basis.

Conclusions

The literature on the use of student response systems (clickers) and online homework is mixed and it appears that studies that found differences used assessment questions tightly associated to the clicker questions.[22,24,31] Additionally, Bunce *et al.*[17] found that students who used online quizzes performed significantly better on teacher-written exams than a standardized ACS exam. In this study, we used a nationally standardized exam ACS GC97 as a measure of students' knowledge since our goal was to evaluate whether these instructional methods improved students' ability to answer questions that were not written by their instructor.

Our data also indicated that there was no significant difference in long-term chemistry content retention among any of the instructional methods tested. These findings are consistent with the existing literature on clickers.[24-25,27] One explanation that the online homework group in our study did not outperform the lecture-only (control) group is that the students who were in the control group were assigned in-book

homework. Hence online homework versus in-book homework should not really see much difference (as long as they are doing it) as indicated by studies that compared online homework versus paper-based homework.[13,35-38] Additionally, the results of this study might have been confounded by instructor effect since different instructors were involved in teaching the three groups.

Studies of long-term retention are often plagued by attrition and a loss of participants[41] and this study is no different. Although the clicker group originally had 153 students in the three Spring semesters and 112 students earned an A, B, or C, only 38 of these students enrolled in General Chemistry II the next Fall and took the ACS final exam. Looking at the number for the online homework group and lecture-only group across the same period of time, one noticed that dramatic attrition is found in all of the three groups, but more students were retained both in clicker and online homework classes than lecture-only classes.

Implications. The questions posed in this study are vital for the future of chemical education at universities such as this regional comprehensive university, since the reductions in state support cannot be offset by forever increasing student tuition. Larger classes seem inevitable and one wonders; must long-term learning of chemistry suffer as a consequence? Our study investigated whether the use of clickers or on-line homework could offset the drawbacks of larger class sizes. Unfortunately, our sample sizes were too small to validate the positive long-term trends that could be present. We can conclude using instructional techniques that increase student feedback enhances retention in the course sequence without any negative impact on performance.

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CHAPTER THREE: EFFECT OF ONLINE HOMEWORK ON STUDENTS' ACHIEVEMENT IN GENERAL CHEMISTRY

Abstract

This study describes the effect of online homework versus no graded homework on students' performance in General Chemistry I course taught by two similar instructors in the same semester. Students' performance was measured using teacher-prepared final exam common questions. The analysis showed that students using online homework for General Chemistry I course performed significantly better on the exam common questions than students using no graded homework. The study also reports a comparison of students' performance in general chemistry I course taught by a single instructor over several semesters using no online homework, WebAssign online homework, or online web learning (OWL) as measured by final exams containing the same questions. The results indicated that students using OWL significantly outperformed students using WebAssign on the final exam. While students using OWL gained nearly an average of 5% higher than students using no online homework, the difference was not statistically significant. These findings suggest that online homework is either more beneficial than, or at least as effective as, no online homework; and that the type of online homework systems used to assign homework can impact students' performance.

Introduction

Student achievement in general chemistry depends on several factors: Student prior knowledge, abilities, learning environment, and method of instruction.[1-5] Of these factors, teachers have more control on the method of instruction, which can be used both inside classroom and outside of the classroom. Students also need to do something beyond lecture attendance to be successful in chemistry. Accordingly, various instructional strategies/ technologies have been incorporated in the teaching-learning process in an attempt to help students learn the course material and improve their achievement in general chemistry. One of the technologies, which has been used in higher institutions to keep students engaged in learning activities outside of classroom, is online homework systems. Online homework provides students more opportunity to practice concepts recently introduced in class and receive immediate feedback for their work. The focus of this paper is to determine whether online homework really helps students learn chemistry concepts and problem-solving.

Selected Literature

Most of the literature regarding online homework (OHW) has focused on either examining the effect of online homework versus no graded homework or comparing the effectiveness of online homework versus traditional paper-based homework on students' performance.

Examining the Effect of Online Homework versus No Graded Homework. Various studies examined students' performance in a particular course to see whether the addition of online homework would make a difference in students' learning outcomes. Some of these studies had no control groups[6-8] while others evaluated students' learning outcomes relative to those students who took the course in the previous semester or year.[9-11] These studies indicated that online homework significantly improved students' performance on teacher-written exams,[6,10] significantly increased students' success rate as measured by the number of students who earned final course grades of A, B, or C,[7,11] or motivated students to complete more quizzes than required for the course.[9,11] Only one of these studies found a weak positive correlation between students' online homework scores and teacher-written exam scores.[8]

Comparing the Effectiveness of Online Homework versus Traditional Paper-Based Homework. Studies that compared the effect of online homework to that of traditional paper-based homework found inconsistent results. Several studies showed that students who used online homework significantly outperformed those who used traditional paper-based homework.[12-18] Others found no significant difference between students' performance using online homework and traditional paper-based homework, indicating that using online homework was as effective as traditional paper-based homework in improving students' performance.[19-25] One of the studies[20] that found no significant difference described that their study was confounded since students using paper-based homework had gained access to their friends' online homework.

There were also other studies that compared the effect of online homework (or quizzes) to that of clickers[26] or intelligent tutorial systems (systems that differ from online homework mainly by their nature of feedback and amount of instructional support they provide to students).[27] For instance, when comparing students' performance on teacher-prepared exam questions related to online quizzes or clickers versus those questions that were not related to the online quizzes or clickers, Bunce *et al.*[26] found that the students using online quizzes outperformed the students using clickers. However, the study by Bunce *et al.*[26] did not find a significant difference on students' performance on the standardized American Chemical Society (ACS) exam as the result of using clickers or online quizzes.

Another study[27] compared the effect of online homework versus intelligent tutorial system, which permits students to ask questions and receive feedback needed to solve a specific problem. Unlike online homework, the intelligent tutorial system provides more instructional support such as giving context-specific answers to students' questions about concepts or applications of concepts. The results from this study indicated that students using the intelligent tutorial system reached mastery level faster than students using online homework system, as measured by gain scores. Gain scores, which measure performance improvements over time, were calculated by subtracting students' Test 1 scores from their Test 2 scores, their Test 2 scores from their Test 3 scores.

Generally, the literature on online homework indicates that using online homework is either more beneficial than, or at least as effective as, traditional paper-

based homework. However, general chemistry instructors are still trying to determine whether online homework is worth the time and effort required to implement it.

Theoretical Framework

Studies suggest that combining a constructivist perspective and a mastery learning approach is worthwhile.[28,29] The constructivist perspective states that learners should actively construct their own knowledge and impose meaning through their existing knowledge structures.[30,31] The mastery learning approach also assumes that students, given sufficient time to practice and repeated testing opportunities with feedback to each learning activity, can fully understand materials discussed in a lesson.[32,33] Therefore, the researcher assumes that using an effective and a well-designed online homework system can help students build accurate knowledge and achieve mastery level understanding of materials introduced in class.

The purposes of this study were: i) to investigate the effect of online homework on students' achievement in a first-semester general chemistry course (GC I) by comparing their performance on teacher-prepared final exam common questions for students using online homework and for students not using online homework (Section One); and ii) to compare performance of general chemistry I students taught by a single instructor over several semesters using no online homework, WebAssign online homework, or OWL online homework on their final exams, which contained the same questions (Section Two). The findings from this study would provide more and recent

data to instructors and educational decision makers on how the use and type of online homework systems impact student learning.

Method

Section One: Online Homework versus No Graded Homework Using Similar Instructors

Participants

The participants for section one of this study consisted of 120 undergraduate students enrolled in two first-semester general chemistry classes taught by two similar instructors during the Fall 2009 semester at regional comprehensive university. One of the classes used online homework (n = 86), and the other used no graded homework (n = 34). The two instructors have taught chemistry at college level for over 10 years, had Ph.D. in chemical education, and were full professors during this study. The instructors had very similar teaching styles: i) focused on active learning including problem solving by students in class, ii) assigned problems from the textbook that were ungraded, iii) gave quizzes frequently to encourage students to keep up, and iv) engaged in regular discussions on how to better teach the course. The major difference between these two classes was that one used online homework and the other did not.

Material and Instruments

Online Homework System. The online homework assignments were given to students on a weekly basis. The number of online homework assignments for each week varied from 10 to 12 problems or questions. Students were allowed up to four tries to correctly answer every question before the due date. In addition to the online system,

both groups were given a list of questions from the book that they should be able to answer, but these homework assignments were never collected or graded.

Teacher-Prepared Final Exam Common Questions. The archival data on teacher-prepared final exam common questions of two sections were collected. The exam common questions were prepared by the instructor who taught students using online homework for General Chemistry I course during Fall 2009. The common questions consisted of 20 multiple-choice items, two of which were matching particulate drawings to descriptions, chemical equations, or reactions.

Data Analysis

The independent samples Welch *t*-test was used to compare the mean scores of the online homework and no graded homework groups on the final exam common questions. Once a significant difference was found, the percentages of online homework and no graded homework students who correctly answered each question were compared and tabulated to see whether there was a significant difference between online homework and no graded homework students' performance on each of the 20 final exam common questions. For this purpose, a test of proportions[34] was calculated for each of the common questions. Pearson's correlation was also performed both within online homework and within no graded homework students to investigate whether their performance on the common exam questions (CommonQs) was correlated to their performance on the other questions (OtherQs) in the same final exam.

Section Two: Same-Instructor Longitudinal Comparison

Participants

The participants in section two of this study were 416 undergraduate students who were taught general chemistry I course by a single instructor over five years using either no online homework (n = 76), WebAssign online homework (n = 168), or OWL online homework (n = 172). The instructor was one of the teachers who participated in section one of this study.

Material and Instruments

Online Homework Systems. Two different online homework systems (WebAssign and OWL) were used in the second section of this study to give homework assignments on a weekly basis. The online homework assignments for each week varied from 10 to 12 problems or questions. Students were allowed up to four tries to correctly answer every question before the due date, which was typically seven days after the assignment was made.

Teacher-Prepared Final Exam. The archival data on teacher-prepared final exams were collected from a single instructor who taught general chemistry I without online homework for one year (F06), then taught using WebAssign two years (F07, F08) and OWL for two years (F09, F10). The final exams, which contained the same questions, were prepared by the same instructor who taught the three groups and included multiple-choice items, short-answer, numerical and conceptual problems, and matching particulate drawings to descriptions, chemical equations, or reactions.

Data Analysis

In section two of this study, Welch analysis of variance (Welch ANOVA) with pairwise comparisons was conducted. The Welch ANOVA, because of unequal experimental and control group sizes, was employed to determine whether there was a statistically significant difference on students' performance among the three groups who were taught using instructional methods facilitated by OWL, WebAssign, or no online homework approaches. Games-Howell post-hoc test was used to perform the pairwise comparisons. In this study, the statistical analyses were performed using Predictive Analytics Software (PASW) Statistics version 18 (SPSS Inc., 2009),[35] and the proper IRB approval was obtained to retrieve all the archival data.

Results and Discussion

Section One: Online Homework versus No Graded Homework Using Similar Instructors

The average score on the final exam common questions for the students using online homework was 69.53/ $\bar{x}$ (SD = 15.12, n = 86) while the average score for students who did not use the online homework was 54.12/ $\bar{x}$ (SD = 17.03, n = 34). The Welch t-test for independent samples indicated that these average scores were significantly different, t (55) = 3.52, p = .001. This result suggests that online homework does have a positive effect on students' performance for the final exam common questions and that using online homework assignments improved students' achievement in General Chemistry I course as measured by a teacher-prepared test.

Comparing the Common Questions to the Other Final Exam Questions

In order to determine whether the exam common questions were representative of the final exam overall, a Pearson's correlation was calculated between the final exam common questions (CommonQs) and other exam questions (OtherQs) in the online homework students. The Pearson's correlation indicated that performance of online homework students on exam common questions and the other questions on the final exam were statistically strongly correlated, $r\,(84) = .72, p < .001$. This correlation indicated that students who did well on the final exam common questions also performed better on other questions and suggests that the exam common questions were representative of the questions on the final exam as a measure of students' performance in the general chemistry I course. Figure 3.1 shows a plot of the correlation between the two sets of questions for the online homework students (plotted as percentage of scores).

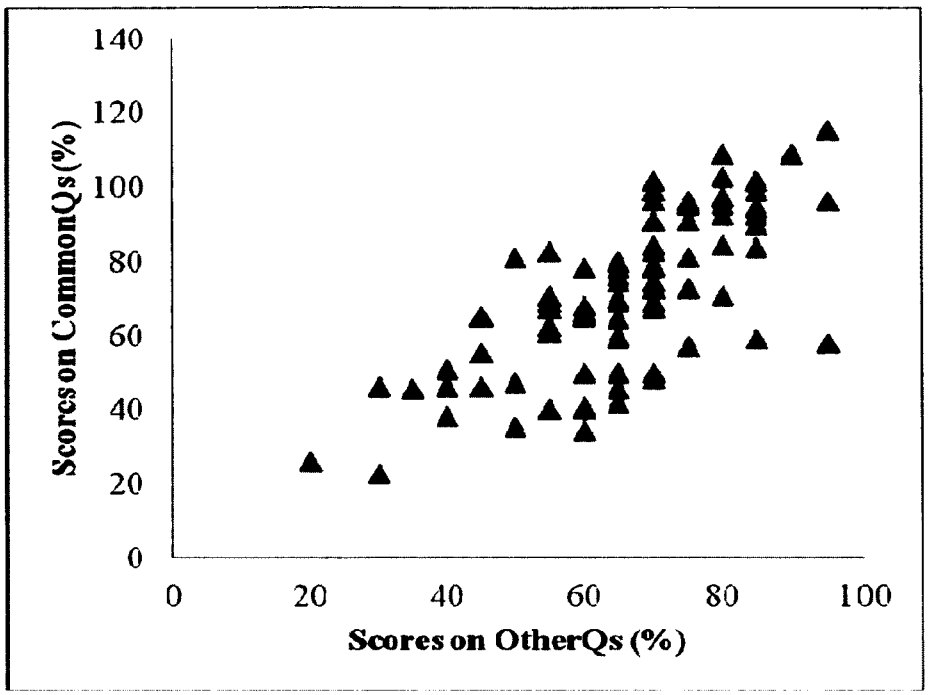


Figure 3.1. Correlation between percentage scores on exam common questions and percentage scores on the other questions on the final exam for the online homework students (*Note.* Scores above 100% are due to extra bonus points)

Pearson's correlation was also calculated to determine whether there was correlation between final exam common questions (CommonQs) and other exam questions (OtherQs) scores for the students who did not use the online homework. The performance of these students on the exam common questions and the other questions on the final exam were also significantly correlated, $r\,(32) = .59$, $p < .001$. This moderately positive correlation indicated that students who did well on the final exam common questions also performed well on other questions on the same final exam. This suggests that the exam common questions were also representative of the questions on the final exam for the students not used online homework. However, this correlation was not as

strong as the correlation for the online homework students. One explanation is that the instructor who taught the online homework students wrote the 20 best final common questions used in this study. Figure 3.2 shows a plot of the correlation between the two sets of questions for the students not used online homework (plotted as percentage of scores).

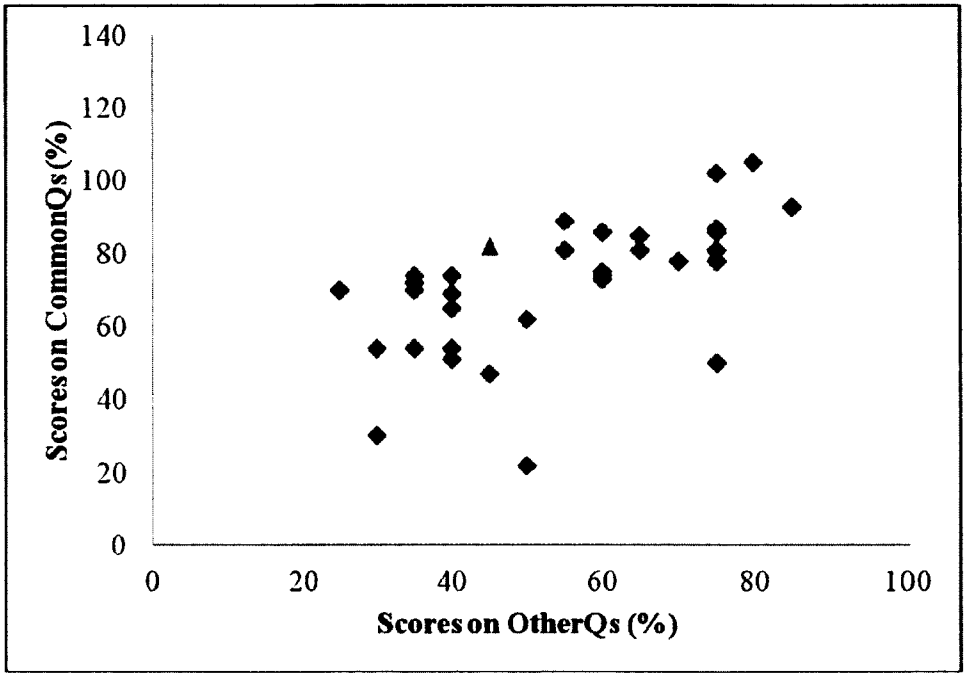


Figure 3.2. Correlation between percentage scores on exam common questions and percentage scores on the other questions on the final exam for the students not used online homework. (*Note.* Scores above 100% are due to extra bonus points)

Comparing Student Responses to the Common Final Extra Questions

Since the *t*-test showed that the students using online homework outperformed the students who did not use online homework on the 20 final exam common questions, a test of proportions[34] was calculated for each of the 20 questions using $\alpha = 0.05/20 = 0.0025$ (The *Z*- scores for each question appear in Table 3.1). These tests indicated that the percentages of students using online homework who correctly answered questions 5, 6, 17 were higher than the percentages of students not using online homework who correctly answered these exact same questions. The percentage differences in percent scores between the two groups of students for each question appear in Table 1. The line chart for the percent of students using online homework and not using online homework who correctly answered each item is shown in Figure 3.3.

Table 3.1. Percentages of No Graded Homework and Online Homework (OHW) Students who correctly answered each of the 20 Final Exam Common Questions

Item No.	% Students who correctly answered		Difference (%)	Z-score[a]
	OHW (n = 86)	No graded homework (n = 34)		
1	98	94	4	0.98
2	60	53	7	0.75
3	44	47	-3	-0.29
4	85	71	14	1.79
5	79	41	38	**4.02**
6	81	47	34	**3.76**
7	66	65	1	0.16
8	94	100	-6	-1.44
9	77	65	12	1.34
10	49	35	14	1.34
11	71	56	15	1.58
12	65	56	9	0.94
13	33	29	4	0.33
14	55	26	29	2.79
15	31	18	13	1.52
16	70	74	-4	-0.41
17	55	12	43	**4.28**
18	63	62	1	0.10
19	63	44	19	1.86
20	88	85	3	0.46

[a] The critical Z-value for $\alpha = 0.0025$ (two-tailed) = $\pm$ 3.025.

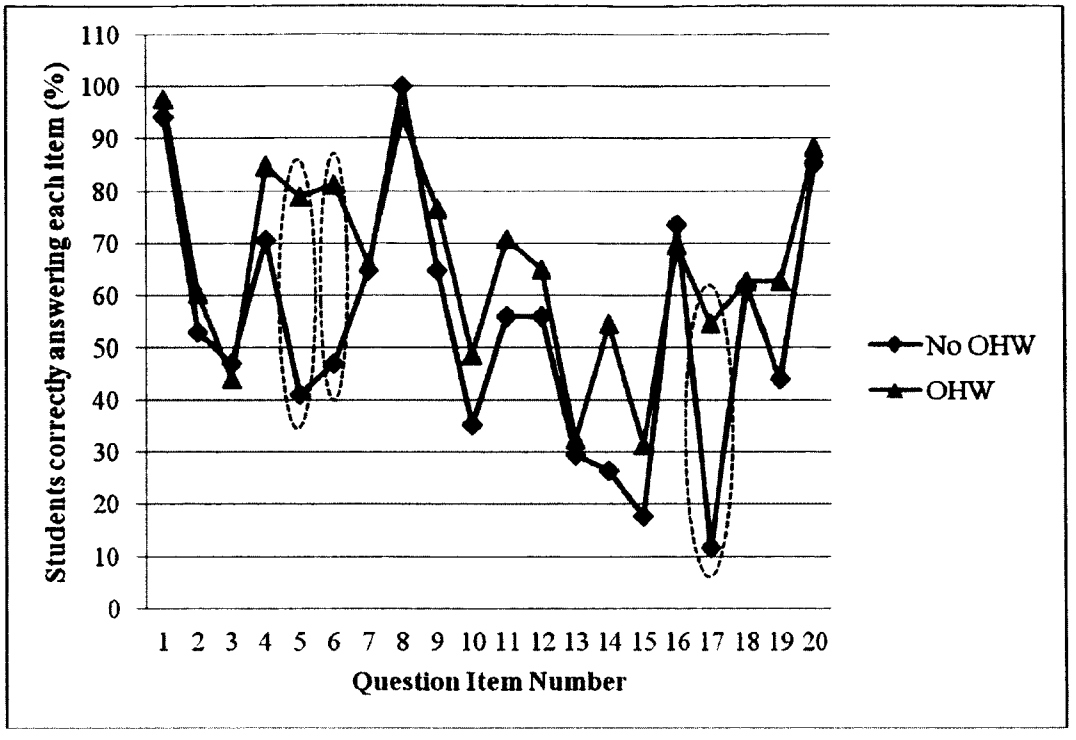
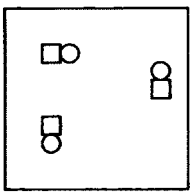
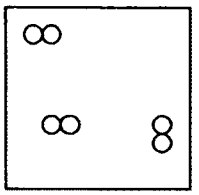
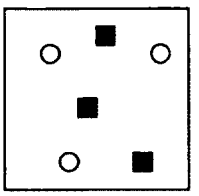
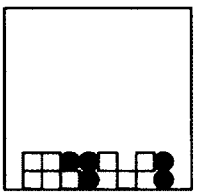


Figure 3.3. Percent of students using online homework and not using online homework who correctly answered each item versus question number (dashed circles indicate where there are significant differences).

The three significant questions require students to either match particulate diagrams to descriptions (questions 5 and 6) or choose best explanation for a concept-based question (question 17). The highest percentage difference was found on question 17. Questions 16 and 17 are related, since question 17 asks students to explain why they chose the answer that they did for question 16. Although a similar percent of students in both groups correctly answered question 16 (70%), 55% of students using online homework correctly answered question 17 whereas only 12% of students not using online homework did so. Questions 5, 6, 16 and 17 are shown in Table 3.2.

Table 3.2. Item Number 5, 6, 16 and 17 of the Common Final Exam Questions

Match the pictures below to the words that best describe them:

a)  b)  c)  d) 

Question 5: Heterogeneous mixture _____
Question 6: Solution _____

Question 16: What happens to the first ionization energy of atoms as you move from across the periodic table from left to right in a period?

a) decreases b) increases c) increases through s block then decreases d) remains unchanged e) no trend is established

Question 17: Which of the following explanations is best to explain why you chose the answer you did in the previous question?

a) Atoms are getting larger as you go across the periodic table
b) Atoms are getting smaller as you go across the periodic table
c) Atoms are increasing in size and then contracting again as you go across a period
d) There is no trend in atom size as you go across a period
e) Atom size is not related to ionization energy

Section Two: Same-Instructor Longitudinal Comparison

Since we were able to collect data from the same instructor who taught GC I without online homework for one year (F06), then taught using WebAssign online homework for two years (F07, F08) and OWL for two years (F09, F10), we decided to compare these students' performance on their final exams, which contained the same questions. Descriptive statistics for teacher-prepared common final exam scores are presented in Table 3.3.

Table 3.3. Descriptive Statistics for Teacher-Prepared Common Final Exam Scores

Group	Year(s)	*n*	$\bar{x}$(%)	*SD*
Experimental group (s)				
OWL	F09, F10	172	67.97	18.72
WebAssign	F07, F08	168	62.76	19.22
Control group				
No Online Homework	F06	76	63.40	15.53

Welch ANOVA was used on the exam scores to determine if the method of instruction influenced students' performance on General Chemistry course I material. Using an alpha level of .05, the Welch ANOVA indicated that there was a statistically significant difference among the three methods (WebAssign, OWL, no online homework) in improving students' performance on General Chemistry I course material, *Welch's F*(2, 220) = 3.70, $p = .026$. Games-Howell post-hoc test indicated that students using OWL ($\bar{x}$ = 67.97, *SD* = 18.72) performed significantly better than students using WebAssign ($\bar{x}$ = 62.76, *SD* = 19.22). The post-hoc test showed no significant differences between students using online homework (WebAssign or OWL) and students using no online homework ($\bar{x}$ = 63.40, *SD* = 15.53) on their General Chemistry exam performance. These findings suggest that the type of online homework system used for general chemistry I can impact students' performance. One possible explanation that OWL was better for students than WebAssign might be because of its mastery learning approach, which allows students work at their own pace until they achieve "mastery" level understanding of each concept

or skill. Additionally, OWL incorporates a variety of questions that include concept oriented, calculation based, or particulate views of reactions or processes, and contains tutorials, chemical simulations, videos, and additional practice exercises.[36]

Conclusions

Using online homework in a general chemistry I course at this regional comprehensive university was found to improve students' performance on teacher-prepared final exam common questions when similar instructors involved in teaching the general chemistry I course in the same semester. This finding is in consistent with the existing literature, which demonstrated that online homework improved students' performance on general chemistry final exams regardless of students' level of preparation and over multiple classes, multiple instructors and multiple years.[6] More specifically, students using online homework did significantly better on questions that included matching particulate diagrams to descriptions and choosing correct explanation to conceptual problems.

Students using OWL online homework system performed significantly better on common exam questions when a single instructor was involved in teaching the course over several semesters. Unfortunately, students' using online homework (OWL or WebAssign) did not do better than students using no online homework. This finding supports the well documented research studies on the comparison of online homework versus traditional paper-based homework.[19-20,22-23,25] In general, online homework was found to be either more beneficial than, or at least as effective as, no online homework, and that the type of online homework system used can impact students' performance. The

findings from this study also revealed that online homework may be used to foster students' performance on specific types of questions.

Implications for Instructors. Instructors can consider using online homework to foster performance of students on specific types of questions without affecting student learning. Instructors need to be careful when selecting the type of online homework system for their courses since different online homework systems may impact students' performance differently.

Future studies. In an attempt to control instructor effect, we did two studies one using similar instructors in the same semester and one using the same instructor over several semesters. However, future research in this area should involve replicating this study using large sample sizes and incorporating a single instructor with multiple sections. Researchers should also examine students' and instructors' attitudes toward using online homework to determine how their perceptions are related to one another and how they might impact students' learning.

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CHAPTER FOUR: STUDENTS' ATTITUDES TOWARD USING ONLINE HOMEWORK

Abstract

This study reports students' attitudes toward the use of online homework for general chemistry courses. For this purpose, online surveys were administered in Fall 2009, Spring 2010, and Fall 2010 semesters. The surveys contained questions about student characteristics/demographics, prior achievement, homework practices, and attitudes about the perceived benefits of online homework. The study investigated whether there was a correlation between students' characteristics and any of the perceived benefits of online homework, finding none of the student characteristics was significantly correlated with the perceived benefits. Students' responses to an open-ended question were also coded and emerging themes and their implications are presented.

Introduction

Various technologies have been adopted in teaching different courses at different levels to help students engage in active learning both inside and outside classrooms. Online homework is one of such technologies that attempts to help students practice course materials outside classroom, have a better conceptual understanding of the material, provide feedback in real time, and thereby improve their learning. These technologies become even more important as class sizes continue to grow making one on one feedback between instructor and student more difficult to give in a timely manner. Unfortunately, incorporating technology into instruction on its own does not necessarily

guarantee enhanced achievement of the perceived learning outcomes since several factors can affect the effectiveness of the technology. For instance, as Smolira[1] describes, user's perception about a technology considerably determines the benefit and usage of that technology. Therefore, students' attitudes toward online homework are as crucial to its success as any other variable. This paper intends to report students' attitudes toward the use of online homework in an effort to inform this important factor in effective implementation of this technology.

Selected Literature

Studies that have explored students' attitudes toward online homework indicated that students either had positive attitudes toward using online homework in chemistry[2-4] or perceived online homework as effective as paper-based homework to prepare for tests.[5] For instance, the survey results from the Richards-Babb *et al.*'s study[4] i) showed that students had positive attitudes and recommended online homework be used for future classes, and ii) pointed out that there was a high percentage of homework completion in general chemistry courses.

Arasasingham *et al.*[2] surveyed students' attitudes toward online homework in General Chemistry courses, finding that students felt that online homework helped them learn the course material. The study also described that most faculty felt that online homework i) kept the class on task and on track; ii) was a better system than paper-based homework or in-class quizzes; and iii) enabled students to work at their own pace with a large number of practice problems. Another survey[3] of students' perceptions about the effectiveness of an online homework program in organic chemistry found that students

perceived the online homework program as a helpful tool for improving their performance on exams. Frnewever[5] investigated students' perceptions of the usefulness of paper-based homework and online homework using the technique of Small Group Instructional Diagnosis (SGID), finding that students perceived that both online and paper-based homework were equally helpful to prepare for quizzes and exams in General Chemistry course.

Studies in non-chemistry disciplines also showed that most students had positive perceptions about online homework.[6-12] For instance, Jacobson[10] found that students perceived the computer homework assignments as a helpful tool for learning the pre-algebra course material. Another study on students' perceptions about online homework pointed out that most students perceived the online homework system as an effective method of homework delivery in college accounting principles classes.[7]

Smolira[1] examined students' perceptions about using online homework in an introductory undergraduate finance and in a prerequisite MBA graduate finance classes. Responses to a questionnaire conducted in this study indicated that students i) preferred online homework to paper-based homework because of the immediate feedback, and ii) felt that online homework helped them understand the material and increased the time they spent in preparing for the class. His study also found that MBA graduate students had a higher degree of satisfaction with the online homework than did undergraduate students. Jones's study[11] showed that most students (71.1%) felt that online homework systems improved their learning in an introductory accounting course, and more than

one-third of the students in this study reported that using online homework did not increase their interaction with the professor in the course.

In some cases, the positive perceptions held by students were not necessarily reflected in positive students' performance.[6,10] A study on students' attitudes toward online homework in different economics and introductory business statistics courses at the university level revealed that i) a majority of students reported that online homework was as effective as paper-based homework, ii) students' self-reported grade point averages and course specific motivation were strongly related to positive student attitudes toward online homework, but iii) students' attitudes about online homework were not related to students' learning styles and demographic characteristics.[8] Inconsistent with Doorn *et al.*'s findings[8], Dillard-Eggers *et al.*[7] showed that demographic characteristics, particularly age was related to students' perceptions about online homework in accounting principles classes, finding that younger students had more positive perceptions about using online homework ($p = .059$) although older students completed more homework.

In general, a review of literature indicated that results of studies, especially on whether students' attitudes toward online homework are related to their characteristics or performance on course exams are not consistent and inclusive. This suggests that there is still a need of further investigation to completely and deeply understand how students' attitudes about online homework impact their learning of course materials. Therefore, this study was undertaken in an attempt to investigate students' attitudes toward using online homework, especially in General Chemistry I and II courses.

Method

Participants

The participants in this research consisted of a total 462 students (of 2258 students) who were enrolled in General Chemistry I or II (GC I or GC II) courses at a regional comprehensive University in Fall 2009, Spring 2010, and Fall 2010 semesters. General Chemistry courses are offered every semester (Fall, Spring, and Summer) to first-year students who intend to major in chemistry, biology, or engineering technology, and to those who are interested in pursuing one of the pre-health programs (Pre-Pharm, Pre-med, Pre-dent, or Pre-vet.). It is common to see sophomore, junior, senior, and even graduate students taking these courses as a general or supporting requirement in another discipline (as it was confirmed by the online survey). Hence the participants in this study were much more diverse in their intended majors than might have been predicted.

Material and Instruments

Online Survey. The online survey was based on the interest of the researcher and issues found in the literature[8]. It was comprised of questions regarding students' demographics, prior achievement, homework practices, and students' attitudes toward online homework. The survey was administered using Survey Monkey, a commercially available online program.

Online Homework System. The online homework assignments were given to students on a weekly basis using an Online Web Learning (OWL) system for chemistry. OWL delivers assignments to students, grades their responses instantly, and provides

immediate feedback. The number of online homework assigned for each week varied from instructor to instructor. However, on average instructors assigned 10 to 12 questions or problems per week for General Chemistry (I and II) courses. Students were allowed up to four tries to correctly answer each question prior to the due date. In addition to homework assignment, some instructors suggested problems from textbook that were not for a grade and not even intended to be checked but rather to highlight important skills and concepts in the text and provide more practice for students.

Data Collections

The following data collection procedures were used in this study for investigating students' attitudes toward online homework: After the approval of Institutional Review Board (IRB) of the University, an email was sent to each potential participant to ascertain their willingness to take part in the study. Those who were interested in being part of the research completed the informed consent, which was included on the front page of the online survey, and those who did not complete the informed consent were automatically excluded from the study.

The online survey was conducted during the final two weeks of Fall 2009, Spring 2010, and Fall 2010 semesters. The survey administered in Spring 2010 and Fall 2010 was a modified form of Fall 2009 and had more online homework related questions, which were not included in the Spring 2009's survey. A copy of the online survey questions is included in Appendix B. The results from the online survey were analyzed to assess students' homework behaviors, practices, and attitudes as well as their demographic data.

Results and Discussion

Multiple instructors were assigned to teach General Chemistry I and II courses due to the departmental need for multiple sections. During the traditional three hours weekly allotted for class, some instructors gave quizzes on a regular basis or used clickers during classroom sessions. The instructors also assigned different out of class assignments including online homework, textbook based homework or suggested problems to engage their students in learning activities, and improve student learning of General Chemistry I or/and II courses. Our study primarily focused on investigating the attitudes of students who used online homework in General Chemistry I or/and II courses to understand how students' attitudes regarding online homework impacted their learning of course materials and/or are related to other student characteristics.

The online survey contained the following demographic characteristics: age, gender, major (or intended major), year in school, self-reported GPA, and expected grade in General Chemistry course in which they were enrolled. This demographic data were used to classify students in an attempt to identify patterns in attitude responses. The responses to the questions that were related to homework practice/experience/behavior, online homework attitudes and the effectiveness of the homework delivery method have been thoroughly studied and analyzed using constant comparative analysis method[13], in which categories were established in hopes of finding patterns of responses to better inform the use of online homework systems.

Demographic Data

The demographic data of participants for Fall 2009 (F09), Spring 2010 (S10), and Fall 2010 (F10) survey indicated that a majority of students participated in this study were in their first or second years of college (F09 = 60.2%, S10 = 60.3%, and F10 = 68.7%), and were in the age range of 18-23 (F09 = 77.5%, S10 =77.1%, and 82.0%). The majority of the participants also had a self-reported GPA between 3.00 and 4.00 (F09 = 64.2%, S10 =68.1%, and 64.1%). In all semesters, there was a greater number of female participants (F09 = 60.3%, S10 = 65.1%, and F10 = 62.8%) than male participants. Results are included in Tables 4.1, 4.2, and 4.3. The participants (about 70% in each semester) were taking 13-17 total credit hours.

Table 4.1. Student Sample Characteristics in Percent – Fall 2009 (Female = 60.3% and Male = 39.7%)

Age	(%)	Academic Classification	(%)	Self-reported GPAs	(%)	Expected Grades	(%)
18-20	57.0	Freshman	36.4	< 2.00	2.0	A	22.5
21-23	22.5	Sophomore	23.8	2.00-2.49	6.6	B	34.4
24-26	7.9	Junior	19.2	2.50-2.99	25.2	C	23.2
27-30	6.6	Senior	15.2	3.00-3.49	33.1	D	7.9
> 30	4.6	Graduate	2.0	3.50-4.00	31.1	F	1.3
DNR*	1.3	DNR*	3.3	DNR*	2.0	Do not know	9.3
						DNR*	1.3

Note. *DNR = Did not respond. n = 151.

Table 4.2. Student Sample Characteristics in Percent – Spring 2010 (Female = 65.1% and Male = 34.9%)

Age	(%)	Academic Classification	(%)	Self-reported GPAs	(%)	Expected Grades	(%)
18-20	55.4	Freshman	42.2	< 2.00	1.8	A	16.9
21-23	21.7	Sophomore	18.1	2.00-2.49	8.4	B	41.6
24-26	10.8	Junior	18.7	2.50-2.99	21.1	C	28.9
27-30	6.6	Senior	18.1	3.00-3.49	40.4	D	2.4
> 30	4.2	Graduate	1.8	3.50-4.00	27.7	F	2.4
DNR*	1.2	DNR*	1.2	DNR*	< 1	Do not know	6.0
						DNR*	1.8

Note. *DNR = Did not respond. n = 166.

Table 4.3. Student Sample Characteristics in Percent – Fall 2010 (Female = 62.8% and Male = 36.6%; DNR = 0.6%)

Age	(%)	Academic Classification	(%)	Self-reported GPAs	(%)	Expected Grades	(%)
18-20	64.8	Freshman	33.8	< 2.00	4.1	A	28.3
21-23	17.2	Sophomore	35.9	2.00-2.49	8.3	B	23.4
24-26	6.9	Junior	14.5	2.50-2.99	21.4	C	25.5
27-30	6.2	Senior	13.8	3.00-3.49	31.0	D	8.3
> 30	4.8	Graduate	0.0	3.50-4.00	33.1	F	4.1
DNR*	0.0	DNR*	2.1	DNR*	2.1	Do not know	9.7
						DNR*	0.7

Note. *DNR = Did not respond. n = 145.

Time Spent on Homework

Participants were asked how many hours they spent on homework for General Chemistry class in a week and how much time (hours) they thought homework in general, should take for a college chemistry course in a week in an open-ended question. A majority of participants (59.7% in Fall 2009, 59.8% in Spring 2010, and 57.0% in Fall 2010) reported that they spent 2-4 hours per week on doing online homework assignments for General Chemistry course and about half of the participants (51.0% in Fall 2009, 55.0% in Spring 2010, and 49.0% in Fall 2010) felt that homework for a College Chemistry course should take 2-4 hours in a week.

Descriptive Data

Students were asked Likert-scale questions regarding their behaviors and experiences with homework in general, online homework experiences in particular, and where they sought help with homework (online or otherwise). Possible responses were 5 = all of the time; 4 = most of the time; 3 = at least half of the time; 2 = sometimes; and 1= almost never. To make these responses more clear, the results of "all of the time" and "most of the time" were combined together to give positive responses; and "sometimes" and "almost never" were combined to represent negative responses. The result of "at least half of the time" is classified as neutral response. Results are reported in percents in all cases.

General Homework Behaviors or Experiences. The following are descriptions of the results from five general homework survey questions collected in Fall 2009, Spring

2010, and Fall 2010 semesters to which the responses are given in percent. The results indicated that the average percentage of students who would do homework if it were not counted for a grade across the three semesters is 46.1% (with 21.4% responding neutral and 32.5% responding negatively). The average percentage of students who think that people who do homework are more successful in class than those who do not across the three semesters is 77.4% (with 8.2% responding neutral and 14.4% responding negatively). The average percentage of students who do assigned (suggested) problems (if no one checks them or grades them) across the three semesters is 52.1% (with 17.6% responding neutral and 33.5% responding negatively). The average percentage of students who do problems beyond the assigned problems across the three semesters is 18.8% (with 14.0% responding neutral and 66.7% responding negatively). The average percentage of students who read the textbook across the three semesters is 34.2% (with 19.6% responding neutral and 46.2% responding negatively). These results appear in Figure 4.1 and Table 4.4.

Table 4.4. Students Experience with Doing Homework (General Homework Behaviors)

		Fall 2009	Spring 2010	Fall 2010	Average across the three semesters
1.	Do you/Would you do homework that was not counted for a grade?				
	All or most of the time	48.3	43.3	46.8	46.1
	At least half of the time	20.8	22.0	21.3	21.4
	Sometimes or almost never	30.9	34.8	31.9	32.5
2.	Do you think that people who do homework are more successful in class than those who do not?				
	All or most of the time	80.6	75.7	75.9	77.4
	At least half of the time	10.7	6.7	7.1	8.2
	Sometimes or almost never	8.7	17.5	17.0	14.4
3.	Do you do assigned (suggested) problems (if no one checks them or grades them)?				
	All or most of the time	55.4	56.0	45.0	52.1
	At least half of the time	16.9	13.3	22.5	17.6
	Sometimes or almost never	27.7	40.6	32.4	33.5
4.	Do you do problems beyond the assigned problems?				
	All or most of the time	21.5	15.8	20.6	18.8
	At least half of the time	18.1	13.3	10.6	14.0
	Sometimes or almost never	60.4	70.9	68.8	66.7
5.	Do you read the textbook?				
	All or most of the time	42.9	27.9	31.9	34.2
	At least half of the time	24.5	15.8	18.4	19.6
	Sometimes or almost never	32.6	56.4	49.6	46.2

Note. $N = 455$. n (Fall 2009) = 149, n (Spring 2010) = 165, and n (Fall 2010) = 141. Values are given in percent

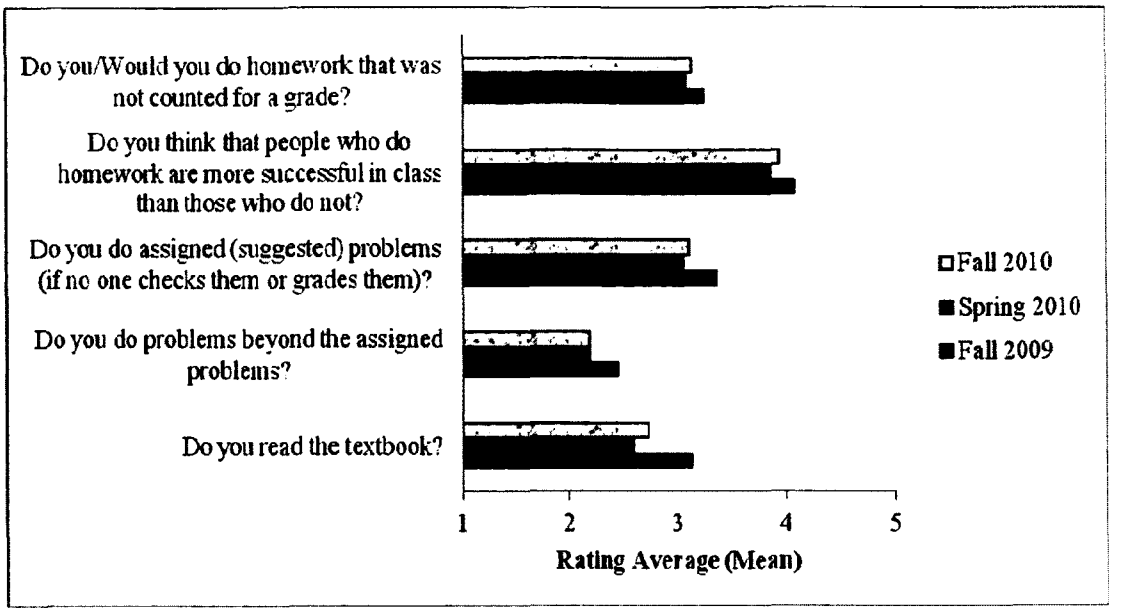

Figure 4.1. Mean of students' responses on five homework practice questions.
(*Note*. 1= Almost never; 2=Sometimes; 3=At least half of the time; 4=Most of the time; 5=All of the time)

Students' Online Homework Experiences. Students were asked about their experiences with online homework. Following are descriptions of the results from five survey questions regarding online homework, which were added after the initial semester. The responses to these questions in Spring 2010 and Fall 2010 semesters are given in percent. The results indicated that the average percentage of students who completed the online homework across the three semesters is 88.1% (with 5.5% responding neutral and 6.4% responding negatively). The average percentage of students who believed that online homework helped them prepare for tests across the three semesters is 53.9% (with 11.1% responding neutral and 35.0% responding negatively). The average percentage of students who believed that online homework helped them understand the material across the three semesters is 50.0% (with 16.8% responding neutral and 33.6% responding

negatively). The average percentage of students who reported that helpful feedback was provided by the online homework system across the three semesters is 49.7% (with 15.8% responding neutral and 34.6% responding negatively). The average percentage of students who reported that they learned more with online homework than paper-based homework across the three semesters is 34.6% (with 20.0% responding neutral and 55.4% responding negatively). These results are given in Table 4.5. Figure 4.2 presents the rating average of students' responses on five online homework statements in 1 to 5 likert-scale.

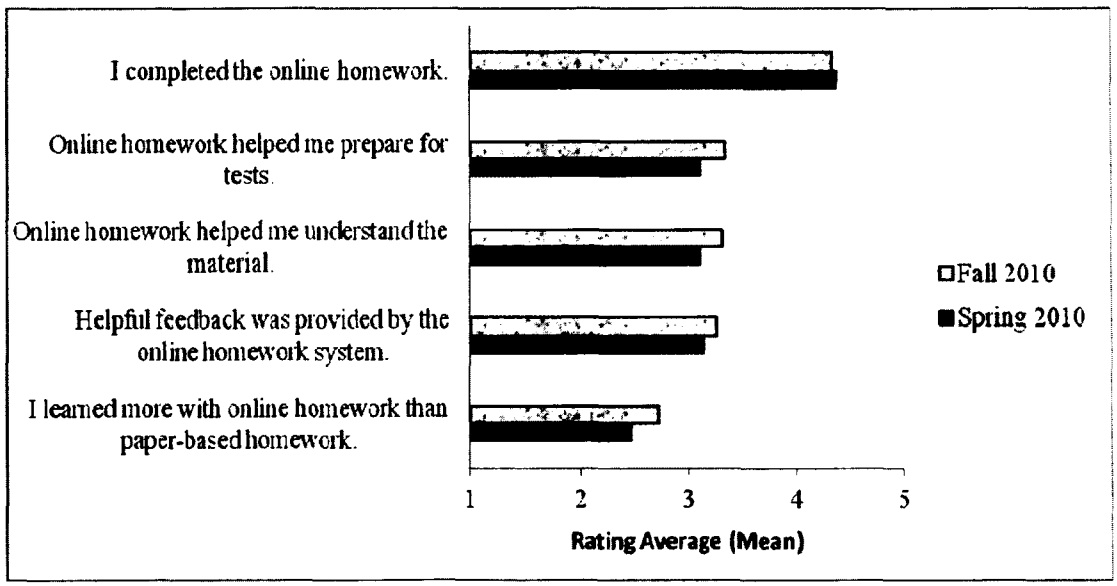

Figure 4.2. Mean (rating average) of students' responses on five online homework statements. (*Note.* 1= Almost never; 2=Sometimes; 3=At least half of the time; 4=Most of the time;5=All of the time)

Table 4.5. Students' Online Homework Experiences. Questions added after Fall 2009*

		Spring 2010	Fall 2010	Average across the two semesters
1. I completed the online homework.				
	All or most of the time	90.4	85.8	88.1
	At least half of the time	4.8	6.2	5.5
	Sometimes or almost never	4.8	8.0	6.4
2. Online homework helped me prepare for tests.				
	All or most of the time	49.3	58.4	53.9
	At least half of the time	11.6	10.6	11.1
	Sometimes or almost never	39.0	31.0	35.0
3. Online homework helped me understand the material.				
	All or most of the time	45.2	53.9	49.6
	At least half of the time	17.8	15.9	16.8
	Sometimes or almost never	37.0	30.1	33.6
4. Helpful feedback was provided by the online homework system.				
	All or most of the time	47.9	51.4	49.6
	At least half of the time	15.8	15.9	15.8
	Sometimes or almost never	36.3	32.8	34.6
5. I learned more with online homework than paper-based homework.				
	All or most of the time	30.1	39.0	34.6
	At least half of the time	10.3	9.7	20.0
	Sometimes or almost never	59.6	51.3	55.4

Note. $N = 287$. n (Spring 2010) = 146 and n (Fall 2010) = 141. * Questions were adapted from Doorn, *et al.*[8]

Participants were asked whether they sought help with their homework (online homework) (Table 4.6) and where they most often received the help they needed.

Table 4.6. Participants who sought Help with their Homework

	Fall 2009	Spring 2010	Fall 2010	Average across the three semesters
Yes	58.6	63	56.1	59.2
No	41.6	37	43.9	40.8

Note. $N = 449$. n (Fall 2009) = 145, n (Spring 2010) = 165, and n (Fall 2010) = 139.

Where Students Sought Help with Homework (Online or Otherwise). Students got help with their homework from different people who they thought were good at the specific subject (General Chemistry) when they need to do so. In this study, students were asked where they were most likely to seek help with their homework (e.g. free help center in Chemistry Department, chemistry tutor, a friend who has previously had the course, etc.). Therefore, this section of the survey focused on reporting where students got help with their homework when or if they needed help.

Following are descriptions of the results from six homework-help survey questions conducted in Fall 2009, Spring 2010, and Fall 2010 semesters to which the responses are given in percentages. The results indicated that the average percentage of students who used the free help center all or most of the time across the three semesters is 7.4% (with 7.4% responding neutral and 85.2% responding negatively). The average percentage of students who sought help from a chemistry tutor all or most of the time

across the three semesters is 13.5% (with 10.7% responding neutral and 77.5% responding negatively). The average percentage of students who sought help from a friend who had previously had this class all or most of the time across the three semesters is 27.9% (with 16.5% responding neutral and 55.6% responding negatively). The average percentage of students who sought help from a family member who is good at chemistry all or most of the time across the three semesters is 12.9% (with 7.5% responding neutral and 79.6% responding negatively). The average percentage of students who sought help from their professor all or most of the time across the three semesters is 14.1% (with 12.8% responding neutral and 73.0% responding negatively). The average percentage of students who sought help from another professor or teacher all or most of the time across the three semesters is 8.8% (with 9.2% responding neutral and 81.9% responding negatively). These results are indicated in Table 4.7. Figure 4.3 presents the rating average of students' responses on six homework help questions in 1 to 5 likert-scale.

Table 4.7. Where Students Sought Help with Homework (Online Or Otherwise)

		Fall 2009	Spring 2010	Fall 2010	Average across the three semesters
How often have you used the free help center?					
	All or most of the time	6.0	11.9	4.4	7.4
	At least half of the time	7.0	8.5	6.7	7.4
	Sometimes or almost never	87.0	79.6	88.9	85.2
How often have you sought help from a chemistry tutor?					
	All or most of the time	13.2	12.9	14.4	13.5
	At least half of the time	8.1	8.6	14.4	10.7
	Sometimes or almost never	78.8	77.1	71.1	75.7
How often have you sought help from a friend who has previously had this class?					
	All or most of the time	35.0	27.1	21.6	27.9
	At least half of the time	10.0	17.8	21.6	16.5
	Sometimes or almost never	55.0	55.1	56.8	55.6
How often have you sought help from a family member who is good at chemistry?					
	All or most of the time	18.0	5.2	15.5	12.9
	At least half of the time	5.0	8.5	8.9	7.5
	Sometimes or almost never	77.0	86.3	75.6	79.6
How often have you sought help from your professor?					
	All or most of the time	17.1	12.7	12.5	14.1
	At least half of the time	15.2	11.9	11.4	12.8
	Sometimes or almost never	67.6	75.4	76.1	73.0
How often have you sought help from another professor or teacher?					
	All or most of the time	9.0	8.6	8.9	8.8
	At least half of the time	7.0	8.5	12.2	9.2
	Sometimes or almost never	84.0	82.9	78.9	81.9

Note. $N = 308$. n (Fall 2009) = 100, n (Spring 2010) = 118, and n (Fall 2010) = 90.

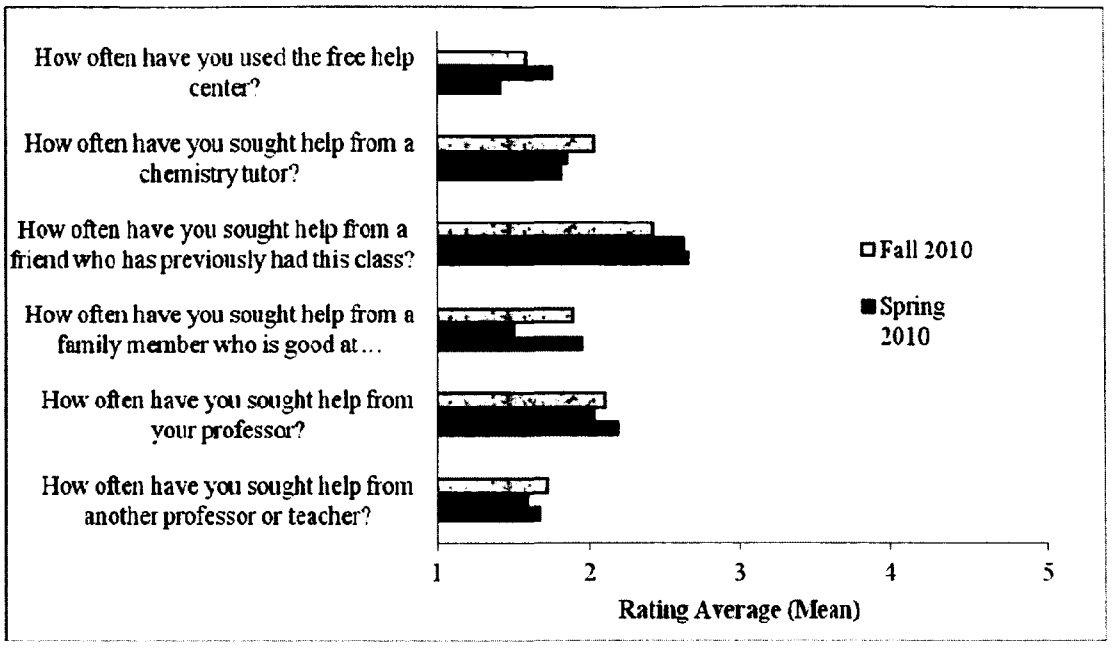

Figure 4.3. Mean (rating average) of students' responses on six homework help questions. (*Note.* 1= Almost never; 2=Sometimes; 3=At least half of the time; 4=Most of the time;5=All of the time)

Analysis of Online Survey

The purpose of this study was to investigate students' attitudes toward using online homework and determine whether there were associations between student characteristics (age, gender, GPA, classification in school) and perceived benefits of online homework. The study used cross tabulation and chi square tests in order to analyze the survey responses.

Cross tabulation between students' characteristics such as age, gender, GPA, and classification in school of participants and the perceived benefits of online homework were performed to identify the possible relationships. The benefits which were analyzed

included: Online homework helped me prepare for tests; online homework helped me understand the material; helpful feedback were provided by the online homework system; and I learned more with online homework than paper-based homework.

Pearson's Chi-square tests[8] were employed to determine whether there was significant relationship between student's characteristics (age, gender, GPA, and classification in school) and the perceived benefits of online homework: online homework helped me prepare for tests (Tests); online homework helped me understand the material (Understand); helpful feedback was provided by the online homework system (Feedback); and I learned more with online homework (Learned). Using an alpha of .05, the Chi-square tests revealed that gender and GPA were significantly associated with one of the perceived benefits (Tests) whereas student's age and classification in school were not associated with any of the perceived benefits of online homework. Table 4.8 presents the summary of chi-square test results. The finding that age was not associated with any of the perceived benefits supports the existing literature.[8] However unlike Doorn's *et al.*'s study[8], this study found that gender was significantly associated with one of the perceived benefits (Tests), but students' classification in school was not associated any of the perceived benefits. The finding from this study was also found to be inconsistent with Dillard-Eggers' *et al.*[7] study, which claimed that students' age was related to students' attitudes toward online homework. In general, results are not consistent as to whether students' characteristics are significantly related to the perceived benefits of online homework or not.

Table 4.8. Chi-Square Test Results

Characteristics	Perceived benefits	*n*	*df*	χ^2	*Asymp. Sig. (2-sided)*
Age	Tests	257	2	.573	.751
	Understand	257	2	1.043	.594
	Feedback	257	2	2.200	.333
	Learned	257	2	.267	.875
Gender	Tests	259	2	7.229	.027*
	Understand	259	2	.590	.744
	Feedback	259	2	.416	.812
	Learned	259	2	.883	.643
GPA	Tests	256	6	15.503	.017*
	Understand	258	6	9.129	.166
	Feedback	258	6	6.707	.349
	Learned	258	6	11.415	.076
Classification	Tests	255	6	10.034	.123
	Understand	255	6	6.814	.338
	Feedback	256	6	9.103	.168
	Learned	255	6	5.667	.461

* Significant at an $\alpha = .05$. Perceived benefits of Online Homework (OHW): OHW helped me prepare for tests (Tests); OHW helped me understand the material (Understand); helpful feedback was provided by the OHW (Feedback); and I learned more with OHW than paper-based homework (Learned).

Responses from Open-ended Question

The open-ended question asked in this study was that "*If homework is defined as anything you do outside laboratory or class, which type of homework delivery method do you believe is more effective? Why?*". Students were given two choices: paper-based homework and online homework as possible answers, and asked to elaborate on why they chose what they chose. Responses from the closed portion of the question are presented in Table 4.9. Of the 462 students, 388 responded to the open-ended question. Some of the participants gave more than one possible reasons, and responses, which were unclear or not relevant to the study, were excluded. (Full responses/comments of students for the open-ended question administered in Fall 2009, Spring 2010, and Fall 2010 surveys are found in Appendix C) The purpose of this open-ended question was to capture participants' attitudes about online homework, particularly those which may not have been addressed in the Likert-scale questions. The explanations were analyzed using the constant comparison method and the summary of most frequently cited responses are presented in Table 4.10. A response is considered frequently cited when given by 15 or more participants.

Table 4.9. Students who chose PBHW* or OHW* as an Effective Method of Homework Delivery in Percent

	Fall 2009 (n = 141)	Spring 2010 (n = 161)	Fall 2010 (n = 141)	Average across the three semesters
PBHW	49.7	58.4	48.9	52.3
OHW	50.3	41.6	51.1	47.7

Note. *PBHW = paper-based homework, *OHW = online homework

Table 4.10. Most Frequently Cited Comments about why Participants chose Online Homework (OHW) or Paper-Based Homework (PBHW) as an Effective Homework Delivery Method

If homework is defined as anything you do outside laboratory or class, which type of homework delivery method do you believe is more effective? Why?"	Count $N = 387$	%
OHW, because		
• OHW provides immediate feedback/ instant grading	104	27
• OHW provides helpful tutorials/explanations/examples	50	13
• OHW is flexible/convenient/accessible/interactive/allows multiple tries	20	5
PBWH, because		
• PBHW is hands-on, easy to remember/understand/learn the course material	72	19
• PBHW is easy to access anywhere/needs no computer and internet connection/no technical problems	20	5
• PBHW has the same format with tests/exams/related to the lecture	15	4
• PBHW is easy to seek help and spot mistakes fast/gives partial credit	15	4
• OHW has glitches/very sensitive answer entry format/gives no partial credit/takes more time/frustrating	64	16
• OHW provides more help than it should/no learning/hints or feedback not clear/guessing until it tells us how to do it /unable to see where you went wrong on a problem	27	7

The most frequently cited positive comments about online homework are both related to feedback. The students valued the fact that online homework provided immediate feedback on the accuracy of their answers and this element of online homework was easily the most cited positive element.

- *I enjoyed using the OWL system more than traditional homework. You are able to get help more easily and you get instant feedback on your answers as well as help from the system to immediately correct your mistakes and gain a better understanding for what you did wrong. (F09/044)*
- *Feedback was available when I had problems with a procedure that helped me learn how to work the problems better. (F10/018)*
- *Online homework systems tend to provide immediate feedback, which is particularly helpful when you've gotten the answer wrong. It allows you to immediately address whatever problem you are having with a particular concept. (F10/037)*

The second most cited reason for preferring online homework was also related to feedback but focused specifically on tutorials and explanations of answers not merely feedback on accuracy of answers.

- *Because it (online homework) had tutorials to help you understand the problem if you didn't get it right the first time. (F09/019)*
- *Because the tutorials helped me to understand what I was doing wrong and helped to guide me to the correct answer and that is not possible the traditional paper/pencil way. (F09/036)*
- *Because if you don't understand the question there are usually tutorials that will explain it and they are easier to understand then[sic] a chemistry book. (F09/042)*
- *b/c[sic] it (online homework) gives the tutorials to help you if you put in the wrong answer. It is very similar to having your teacher at home helping you with your homework. (F09/043)*

Interestingly, the most frequently cited negative comments about online homework are also associated with feedback, specifically the lack of information as to how an

answer should be entered. The students were frustrated when their errors were not necessarily associated with not being able to work the problems or understand the concepts but were associated with entry errors; programming errors, significant digits, rounding, spelling etc.

- *OWL had a lot of errors with the program and it would accept incorrect answers as correct and it would not accept correct answers also. Also the OWL program was more about how you input your answer, it was difficult to understand how the computer wanted you to express your answer. (S10/020)*
- *There were numerous times with OWL that it would not take an answer that was correct but in a different form. For example, it would not take 4.6x10^-3 or 4.6E-3 but it would take 0.0046. It was just frustrating at times. (S10/038)*
- *I personally ran into quite a few errors in the (online homework) system itself where the answer would be counted as wrong simply because of a formatting error or because there was something wrong with the question. This is extremely frustrating and there is nothing the student can do to fix it.(S10/122)*
- *If you don't enter the online answers in the correct way (subscripts, notations) you think your answer is wrong and you end up confusing yourself. (F10/060)*

Conclusions

This study indicated that majority of students (77%) believed that people who do homework should be more successful in class than those who do not, which was supported by a high percentage of self-reported homework completion (88.0%). The study also showed that most students (67.0%) tend not to do problems beyond homework and suggested problems, indicating that most of them are less motivated to do or practice extra problems that do not count for a grade. The study revealed that not many of the

students read the textbook to prepare for class, homework, or exams. The majority of students (55%) reported that they did not learn more with online homework than with paper-based homework. The student's gender and GPA were significantly correlated with one of the perceived benefits of online homework (Tests) while their classification in school or maturity as a student were not associated with any of the perceived benefits. Responses from the open-ended question pointed out that students valued the fact that online homework provided immediate feedback on the accuracy of their answers and this was the most frequently cited positive element of online homework. Some students (19%) also believed that they remember better when they have to write their step-by-step responses down on paper than inputting their final answer into the computer.

Implications for Instructors. Students see homework as a practice where they need feedback and they want to know right or wrong and why - this is also highlighted in what they do not like - the ambiguous feedback or thinking they do not know how to do something because they cannot put the exponent in correctly. Therefore, instructors need to understand that assigning homework or suggested problems by itself does not necessarily guarantee student learning unless they are followed by immediate corrective and diagnostic feedback, which helps students succeed in the course.

Instructors can consider assigning online homework to help students engage in learning activities, gain practice with the course material, and receive feedback in real time outside classroom, particularly when teaching large classes. Instructor may also consider using traditional paper-based homework, if conditions allow, since there are some students who believe that they remember better when they have to write their step-

by-step responses down on paper than inputting their final answer into the computer. Additionally, instructors need to encourage students to gain more practice on conceptual and numerical problems or questions beyond homework and assigned problems, and read their textbooks.

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CHAPTER FIVE: AQUEOUS SYNTHESES OF GROUP 1 METAL TRISPHAT SALTS

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Abstract

Because of its large size, low overall charge that can be dispersed, and electronegative substituents, tris(3,4,5,6-tetrachlorobenzenediolato)phosphate(V) or TRISPHAT anion, $[P(C_6Cl_4O_2)_3]^-$, was studied as a potential weakly coordinating anion. More convenient water-based syntheses of the Group 1 metal *rac*- and Δ-TRISPHAT salts were developed. The *rac*-TRISPHAT salts were synthesized from the parent acid and aqueous metal carbonates, and from tributylammonium *rac*-TRISPHAT and aqueous metal hydroxides. The metal (Cs and Rb) Δ- TRISPHAT salts were synthesized from cinchonidinium Δ-TRISPHAT and aqueous metal hydroxides. The metal (Cs and Rb) Δ-TRISPHAT salts were characterized by IR spectra, optical activity measurements, and, ^{13}C NMR, ^{31}P NMR, and ^{35}Cl NQR spectra.

Introduction

Weakly Coordinating Anions (WCAs)

WCAs are a class of anions in which a few strong interactions with cations are replaced by many weak coordinative interactions.[1,2] WCAs allow one to stabilize strongly acidic species (highly electrophilic metal and nonmetal cations) or weakly bound Lewis acid-base complexes of metal cations.[2]

WCAs should have the following desirable properties:[1]

1. Low overall charge (-1 or -2);
2. High degree of charge delocalization (to ensure even distribution of the charge over the surface of the anion): this ensures that no individual atom or group of atoms bears a high concentration of charge. Larger anions may allow a higher degree of charge delocalization; this and low overall charge are major factors that can make an anion a weak base;[3]
3. Kinetic stability (for example, resistant to oxidation and chemical dissociation); this avoids the following potential problems associated with WCAs. First, some very large weakly coordinating anions could dissociate into smaller, more strongly coordinating fragments. For example, rapid fluoride ion abstraction by electrophiles is well known[4-6] to be a problem with anions such as BF_4^- and PF_6^-. Second, the stability of a weakly coordinating anion with respect to oxidation will determine whether it can be used as a counterion for the most electrophilic cations, many of which will also be strong oxidants. For example, BPh_4^- has a well-known tendency to undergo chemical and electrochemical oxidation.[1]
4. The presence of only weakly basic sites on the periphery of the anion: for example, anions with only hydrogen or halogen atoms available for binding to the cation should be more weakly coordinating than anions with accessible oxygen atoms (for instance, BF_4^- and PF_6^- are more weakly coordinating than ClO_4^- or $SO_3CF_3^-$). Organohalogens are particularly weakly coordinating even to cations that are strong Lewis acids.[1] Therefore, anions such as $CF_3SO_3^-$ and $[B(C_6F_5)_4]^-$

are useful WCAs,[7] and trifluoroacetate is a much weaker nucleophile and a less basic anion than acetate.

5. A WCA can be made softer by the substitution of softer chlorine atoms onto its surface rather than harder fluorine atoms, which might allow it to coordinate more weakly to a hard acidic cation.

In the case of chlorinated WCAs, ^{35}Cl NQR spectroscopy has proved to be a useful tool to assess weak coordination.[8] Wulfsberg *et al.* used this technique to assess the relative basicity of the weakly coordinating chloroacetate anions $CCl_xH_{3-x}COO^-$ and chloromethanesulfonate anions $CCl_xH_{3-x}SO_3^-$ (x = 1-3).[9,10] These anions coordinate weakly to weakly acidic Group 1 cations via oxygen donor atoms. The coordination interaction, being predominantly electrostatic in nature, varies inversely with the metal-oxygen distance, hence inversely with the radius of the cation. ^{35}Cl NQR frequencies are very sensitive to weak interactions, and the average frequencies drop as the radius of the Group 1 cation increases.[9] The slope of the plot of the average NQR frequency versus cation radius is greatest for the chloroacetate ion, indicating that it interacts most strongly with the cation and is therefore relatively more basic. The slope is least for the trichloromethanesulfonate anion, indicating that it is the least basic of the series.[9]

WCAs are also used as counterions when association of a coordinating anion competes with coordination of a weakly bound substrate ligand to the cation.[11] We are particularly interested in metallocene catalysts used in olefin polymerization, which contain very acidic, hard Group 4 metal cations, which are, however, so sterically hindered that they have recently been described as "weakly coordinating cations."[12]

WCAs are desired to pair with a cationic metallocenium moiety so that the more reactive olefin can easily replace the temporarily place-holding anion. If such an anion has hard-base donor atoms such as oxygen, it would be desirable that these be buried within the anion, and sterically prevented from coordinating to the Group 4 metal cation.

TRISPHAT Anion as a Chiral WCA

PF_6^- is not always satisfactory as a WCA, particularly in the presence of strong Lewis acids. Replacing fluoride ions as substituents with much larger chelating substituents such as the 1,2-benzenediolato (catecholato) ligand could offer greater stability, as well as the possibility of chirality. The tris(1,2-benzenediolato)phosphate(V) anion was first identified by Allcock.[13,14] This anion, which is found to be configurationally labile, can be simply synthesized as ammonium salts from pyrocatechol, PCl_5, and an amine.[15]

Lacour *et al.* demonstrated that the introduction of electron-withdrawing chlorine atoms on the aromatic nuclei of the catecholate ligands increases the configurational stability of the resulting tris(3,4,5,6-tetrachlorobenzenediolato)phosphate(V) derivative.[16] This D_3-symmetric TRISPHAT anion, $[P(C_6Cl_4O_2)_3]^-$ (Figure 5.1), can be resolved by an association with a chiral ammonium cation, and is configurationally stable at room temperature in all common organic solvents.[17] The Δ-enantiomer is prepared as the cinchonidinium derivative, which is only soluble in polar solvent mixtures (> 7.5% DMSO in $CDCl_3$).[18] The Λ enantiomer is then isolated as the tri-*n*-butylammonium salt, $[Bu_3NH][\Lambda\text{-TRISPHAT}]$, which is soluble in pure $CDCl_3$ and CD_2Cl_2. These enantiomers (Λ- and Δ-TRISPHAT) have left- or right-handed propeller shape (*M* and *P*

helicity), respectively.[18] TRISPHAT anion is also a valuable asymmetry-inducing and solubilizing reagent for organic, organometallic, metallo-organic, and polymeric substances,[18] properties that can be of use in catalysis.

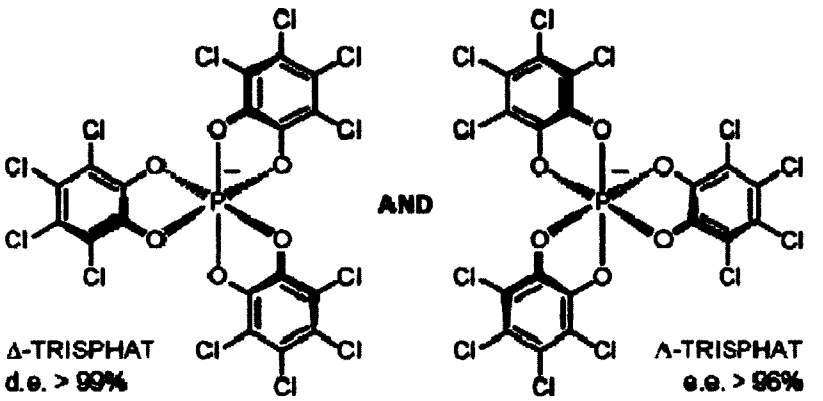

Figure 5.1. The two enantiomers of TRISPHAT anion[18]

In some cases, chiral counteranions can influence the chirality of cation-catalyzed reaction products.[19,20] Because of this and its large size, low overall charge that can be dispersed over the bulk of the counterion, and electronegative substituents, TRISPHAT anion was proposed as a weakly coordinating, very weakly basic anion in zirconocene-catalyzed olefin polymerization.[21]

Recently Lee[21,22] successfully used rac-TRISPHAT as a WCA to enable a zirconocenium cation to polymerize an alkene, N,N-di-*n*-hexylcarbodiimide. They were not successful, however, in using the corresponding zirconocenium Δ-TRISPHAT to induce stereoselectivity in the polymerization. They prepared the catalytic systems

starting with Lacour's tributylammonium rac-TRISPHAT and cinchonidinium Δ-TRISPHAT, respectively. These were converted to the sodium salts by reaction with the powerful base, sodium hydride. The sodium salts were then reacted with trityl chloride to give trityl rac-TRISPHAT and trityl Δ-TRISPHAT, respectively. These then reacted with dimethylzirconocene to give methylzirconocenium rac-TRISPHAT and Δ-TRISPHAT, respectively.

In this research, we propose to model the weakly coordinating, bulky zirconocenium cations with weakly acidic, weakly coordinating Group 1 cations.[3] This research focuses on the syntheses of some Group 1 metal (cesium and rubidium) salts of the TRISPHAT anion using milder conditions, so that the coordinating ability of the TRISPHAT anion could be assessed by studying the NQR frequencies of its Group 1 salts. NQR signals arise from each crystallographically inequivalent chlorine atom in the asymmetric unit of the unit cell. NQR signal-to-noise ratios (S/N) are seldom high, and we expect the signal strength in a racemic TRISPHAT salt to be divided among at least six inequivalent chlorines (three for each anion enantiomer). In the hopes of producing a simpler crystal structure, we decided to synthesize Group 1 salts of a chiral TRISPHAT anion, which might be crystallized with a simpler structure if only one enantiomer of TRISPHAT were present in the lattice.

Experimental section

General Procedures and Characterizations

Most synthetic manipulations were conducted under argon atmosphere or using a Schlenk line under an inert atmosphere of argon. ^{1}H, ^{13}C, and ^{31}P NMR spectra were

obtained on 300 MHz and 500 MHz ECX-JEOL NMR spectrometers. Chemical shifts for ^{13}C NMR spectra were referenced to selected residual proton peaks of the solvent. Chemical shifts for ^{31}P NMR spectra were referenced to a selected residual peak of the cinchonidinium Δ-TRISPHAT in acetone-d_6 solvent. ^{35}Cl NQR spectra were measured at 77K on polycrystalline samples on a Decca Radar NQR-1 spectrometer. The optical activity of cinchonidinium Δ-TRISPHAT, cesium Δ-TRISPHAT and rubidium Δ-TRISPHAT salts were measured using a Rudolph AUTOPOL III Polarimeter.

Toluene (99.8% anhydrous, Acros Organics) was taken by syringe from the original bottle, which was closed with an AcroSeal™. Tributylamine (98.5%, Aldrich) was distilled from KOH pellets under vacuum at about 50°C as described by Lacour. Tetrachlorocatechol (or 3,4,5,6-tetrachlorobenzenediol) (99%, Lancaster) was simultaneously dehydrated and resublimed in 10-g batches in a vacuum sublimation apparatus heated to 170°C-180°C for around two hours. PCl_5 (98%, Acros Organics) was obtained from 5-g bottles sealed under N_2 and opened in a glove bag under argon.

Tri-*n*-butylammonium *rac*-tris(3,4,5,6-tetrachlorobenzenediolato)phosphate (Tributylammonium rac-TRISPHAT) was prepared from TRISPHAT acid using the procedure of Lacour (18). Cinchonidinium Δ-TRISPHAT was prepared from tri-n-butylammonium *rac*-tris(3,4,5,6-tetrachlorobenzenediolato)phosphate and recrystallized by the procedure of Lacour.[18]

Cs *rac*-TRISPHAT acetonitrile solvate from Cs_2CO_3 and TRISPHAT acid. About 0.619 g of Cs_2CO_3 (1.9 mmol) was dissolved in 7.0 mL of distilled water in a mortar and

pestle in an argon-filled glove bag; to this 3.069 g (3.9 mmol) of the freshly synthesized TRISPHAT acid was added. The mixture was ground together until it stopped bubbling. The precipitate was filtered by suction and aspirated dry. The dried salt was then added to 15.0 mL of acetonitrile. The resulting solution was set to dry in a vacuum desiccator over Drierite and anhydrous $CoCl_2$. About 3.06 g of long octagonal crystals were obtained. These were used for NQR analysis and crystallographic characterization. Their ^{31}P NMR spectrum showed a singlet at –80 ppm characteristic of the TRISPHAT anion (16). The ^{13}C NMR spectrum showed peaks at 142 (d), 122, 120, 117, and 114 (d) ppm (d-doublet due to coupling to ^{31}P).

Cesium *rac*-TRISPHAT acetonitrile solvate from tributylammonium *rac*-TRISPHAT and CsOH(aq). 1.909 grams (2.00 mmol) of tributylammonium ***rac***-TRISPHAT, prepared according to Lacour, were dissolved in approximately 10 mL of acetonitrile. Upon addition of 0.62 g (2.0 mmol) of a 50% aqueous cesium hydroxide solution and 5 minutes of stirring, a new gray-white precipitate formed. The solvent was removed by rotary evaporation at 40°C and the tributylamine removed under high vacuum (including heating the flask with a heat gun), leaving 1.831 grams of product, 2.03 mmol (101% yield). The product was dissolved in approximately 30 mL of acetonitrile to form a brown solution for recrystallization over cobalt(II) chloride under dynamic house vacuum. When crystals failed to appear after a week, the sample volume was reduced by rotary evaporation, causing the sample to precipitate. The precipitate was redissolved in acetonitrile, placed in a desiccator, and subjected to dynamic house vacuum. Uniform, transparent and colorless crystals formed 5-7 days later and were

removed, dried and stored under argon in a sealed ampoule at -20°C. NMR spectra of the crystals were obtained in acetone-d_6: -80.6 ppm, 0 ppm (minor), -79.7 ppm (minor) (^{31}P NMR); 141 ppm (doublet), 122.7 ppm, 113.8 ppm (doublet), and 0.3 ppm (^{13}C NMR).

Cesium Δ-TRISPHAT by reaction of cinchonidinium Δ-TRISPHAT with CsOH(aq). 1.06g (1.00 mmol) of cinchonidinium Δ-TRISPHAT was dissolved with 50mL of acetonitrile resulting cloudy solution. 0.6mL (2 mmol) of 50% aqueous CsOH solution was added to it. This resulted in formation of a clear solution; a few crystals settled to the bottom after 15 minutes stirring. The mixture was concentrated by rotary evaporation. The light pink solid was washed with deionized water and aspirated to dryness using a Buchner funnel, then further dried by vacuum pump for 15 minutes, to give 1.07g of crude product ($[\alpha]^{20}_D$ = -313, c = 0.0253 in EtOH). After washing the product with small amount of chloroform, 0.56g of pink solid was collected. ^{13}C NMR (Acetone-d_6, 500 MHz): δ 143.0(d, $J_{C\text{-}P}$ = 6.6 Hz), 123.1, 114.4(d, $J_{C\text{-}P}$ = 19.8 Hz). ^{31}P NMR (acetone-d_6, 500 MHz): δ –80.4. A second crop of 0.16g of white solid was also collected by concentrating the filtrate to dryness.

Rubidium Δ-TRISPHAT by reaction of cinchonidinium Δ-TRISPHAT with RbOH. Using the same method, rubidium Δ-TRISPHAT salt (0.88g, $[\alpha]^{20}_D$ = -385, c = 0.0013 in EtOH) was prepared from cinchonidinium Δ-TRISPHAT and concentrated Rb(OH)(aq).

Optical activities of the metal TRISPHAT salts. The TRISPHAT salts are only slightly soluble in EtOH. Therefore, the compounds (the cinchonidinium- or the metal Δ-TRISPHAT salts) were first dissolved in a small amount of acetone. After concentration,

the compounds were redissolved in 10mL EtOH. The solution was placed in the cell (sample container) of the polarimeter and the observed optical rotations in degrees (α) were recorded. The specific rotations were then calculated: $[\alpha]^{20}_{D} = -369$, $c = 0.0013$ in EtOH for cinchonidinium Δ-TRISPHAT (literature value = -375, $c = 0.111$ in EtOH [18], $[\alpha]^{20}_{D} = -313$, $c = 0.0253$ in EtOH for cesium Δ-TRISPHAT, and $[\alpha]^{20}_{D} = -385$, $c = 0.0013$ in EtOH for rubidium Δ-TRISPHAT.

^{35}Cl NQR spectra. The ^{35}Cl frequencies recorded for approximately 1-g polycrystalline samples of the *rac*-TRISPHAT salts at 77K are shown in Table 5.1. Signal-to-noise ratios are shown in parentheses. The Δ-TRISPHAT salts failed to crystallize, so their NQR spectra could not be recorded.

Table 5.1. ^{35}Cl NQR Frequencies of Group 1 *rac*-TRISPHAT Salts[23]

Cation	Frequency/MHz (S/N)*		Average
$CH_3CN:Cs^+$	37.613(3)	37.539(5)	37.292
	37.318(3)	36.700(3)	
$CH_3CN:Rb^+$	37.713(3)	37.653(4)	37.555
	37.558(2)	37.297(2.5)	
$Bu_3N:Rb^+$	38.147(2)	37.683(2)	37.588
	37.622(2)	37.604(2)	
	37.483(2)	37.381(3)	
	37.194(2)		
$CH_3CN:K^+$	37.700(2)	37.643(2)	37.521
	37.554(1.5)	37.189(1.5)	
$Bu_3N:Na^+$	38.009(2)	37.735(2)	37.718
	37.409(2)		

*S/N is the signal noise ratio

Results and Discussion

The only previous synthesis of any Group 1 TRISPHAT salt was that of Lee [21], who reacted NaH with organic ammonium salts in CH_2Cl_2. We used a different, less drastic method than tolerated the presence of water during the reaction. We found that Group I salts of TRISPHAT could be synthesized by grinding freshly prepared TRISPHAT acid (synthesized as described by Lacour) with M_2CO_3 (M = Cs or Rb) and a little water. The precipitate was quickly filtered, aspirated dry, and recrystallized by slow evaporation in vacuo from acetonitrile to give (in the case of Cs) a water-insoluble but dichloromethane-soluble acetonitrile adduct of Cs(TRISPHAT).

$$M_2CO_3 + 2\ H(TRISPHAT) \rightarrow 2\ M(TRISPHAT) + CO_2 + H_2O$$

These salts showed the characteristic ^{31}P NMR peak at – 80 ppm, and the IR spectra were characteristic of the TRISPHAT anion.[18] The salts were stable for a few months in a desiccator. A crystal structure determination on Cs(TRISPHAT) was undertaken, but was terminated due to slow convergence to a satisfactory R value. (The preliminary result at R = 0.08 indicated a complex structure involving seven-coordinated Cs^+ ions coordinated to one acetonitrile molecule and bridging two TRISPHAT ions by coordination to oxygen atoms.).[24]

We also synthesized TRISPHAT salts of Group I metal cations in high yield ($\geq$80%) by dissolving air-stable tributylammonium TRISPHAT (synthesized according to Lacour) in acetonitrile and mixing with aqueous solution of MOH (M = Cs, Rb, K, Na).

Products synthesized using the above method appeared to contain six coordinate phosphorus atoms (as confirmed by the -80 ppm ^{31}P NMR peak obtained) with minimal evidence of hydrolysis (or solvolysis) products (which characteristically give ^{31}P NMR peaks around 0 ppm). Based on their ^{13}C NMR spectra, all Group I metal TRISPHAT salts (except for cesium TRISPHAT) included tributylamine in the product, presumably coordinated to the M^+ ion.

$Bu_3NH(TRISPHAT) + MOH \rightarrow Bu_3NM(TRISPHAT) + H_2O$ (M = Rb, or K, or Na)

In the case of the rubidium salt, heating the tributylamine adduct under high vacuum gave partial removal of the tributylamine (slow recrystallization from acetonitrile under low pressure gave two types of crystals, one of which had the ^{13}C NMR peaks of butyl groups and one of which did not). Such treatment did not remove the tributylamine from the potassium or sodium TRISPHAT adducts.

The ^{35}Cl NQR spectra obtained for some Group 1 *rac*-TRISPHAT salts (Table 5.1) show less variation with radius of the cation than do the NQR spectra of other weakly coordinating anions previously investigated (Figure 5.2), and are also very little effected by changing the Lewis base attached to the rubidium ion. We must cautiously note that the spectra are weak in intensity, so may not be complete (there should be one signal for each chlorine in the asymmetric unit of the unit cell, and many TRISPHAT crystal structures show large numbers of inequivalent chlorines). If we make the large assumption that the signals detected are representative of NQR signals that were too

weak to detect, then the pattern of variation of average ^{35}Cl NQR frequency versus cation radius is not inconsistent with the notion that the TRISPHAT anion may be even more weakly coordinating to weakly coordinating cations than the trichloromethanesulfonate anion. In turn, this suggests that TRISPHAT anions, which are more easily synthesized than previously thought, might bear investigation for use as weakly coordinating anions in metallocene catalysis.

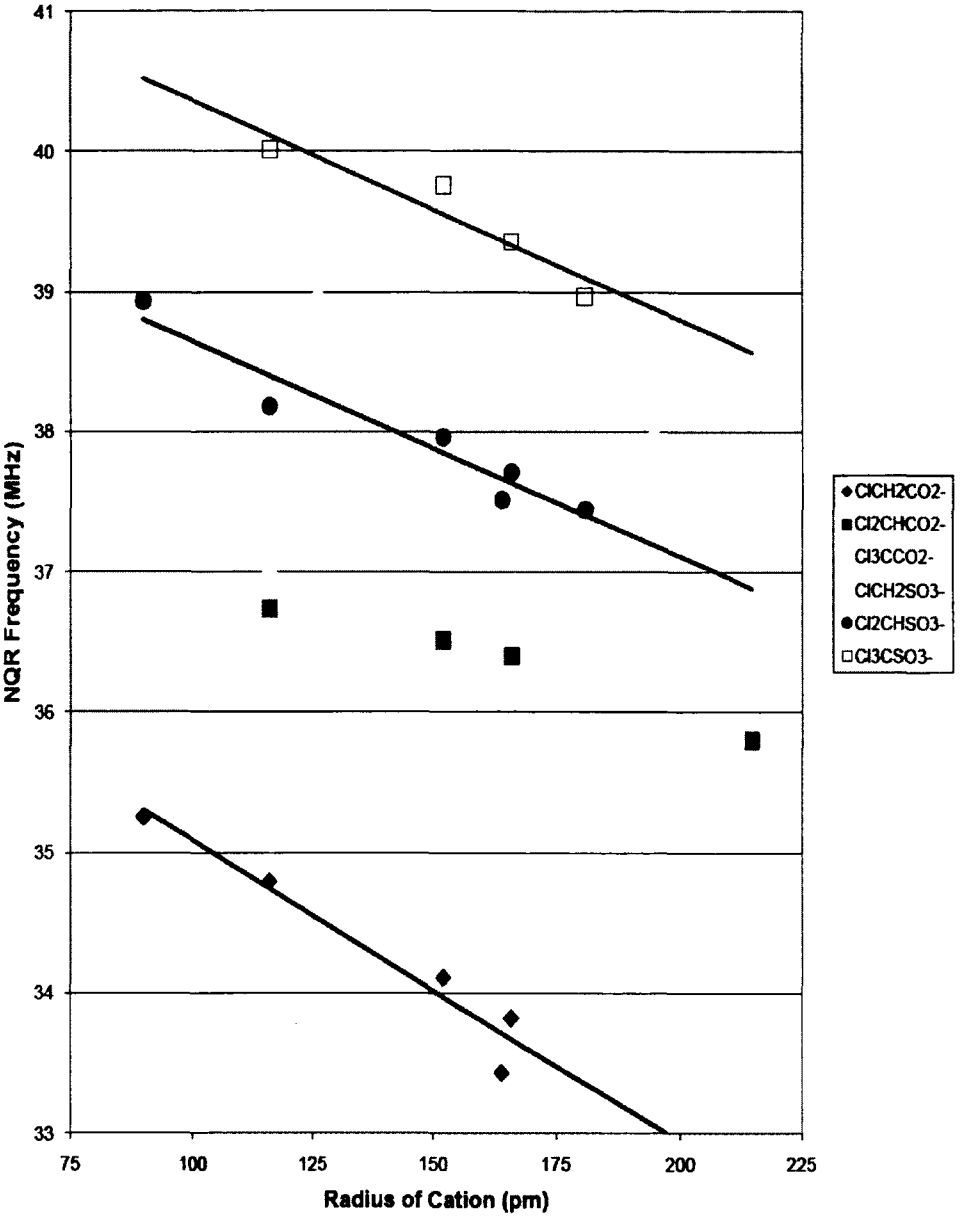

Figure 5.2. Average ^{35}Cl NQR Frequencies (MHz) at 77K of Group 1 Salts of Weakly Coordinating (TRISPHAT, chloroacetate, and chloromethanesulfonate) Anions.[9]

Conclusions

In this research, aqueous methods were used for the first time to make Group 1 metal *rac*- and Δ-TRISPHAT salts. The ^{35}Cl NQR spectra of the *rac*-TRISPHAT salts showed very little variation in average frequency as the Group 1 cation radius was varied. Although these spectra were probably incomplete, this behavior suggests that TRISPHAT anion may be a very weakly coordinating anion that might be worth investigating as a counteranion for metallocene catalysis.

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CHAPTER SIX: GENERAL CONCLUSIONS

Summary of Results

The purpose of this study was three-fold: i) to investigate the effect of clickers versus online homework on students' long-term content retention of general chemistry I course material; ii) to examine the effect of online homework versus no graded homework or no online homework on students' achievement in general chemistry I course using similar instructors in the same semester and a single instructor over several semesters; and iii) to investigate students' attitudes toward the use of online homework. The results from this study indicated that the use of clickers inside the classroom or online homework outside the classroom did not significantly improve students' long-term content retention of general chemistry I course material, that online homework was either more beneficial than, or at least as effective as, no graded homework or no online homework in improving student's performance in general chemistry I course, and that students had neutral attitudes toward the use of online homework for general chemistry courses. The effect of clickers and online homework, and students' attitudes are described under the individual purposes.

Clickers versus Online Homework on Students' Long-Term Content Retention

Long-term content retention of general chemistry I course material was measured using a standardized American Chemical Society Institute (ACS) exam administered seven months after students had completed general chemistry I course. The results indicated that using clickers inside the classroom or online homework outside the

classroom for general chemistry I course did not significantly improve students' long-term content retention when compared to non-clickers, non-online homework (lecture-only) approach. This finding is consistent with existing literature.[1-3] Studies that found significant differences used teacher-prepared exams, which contained questions that were tightly related to clicker questions introduced inside classrooms, to measure students' long-term content retention or performance.[1,4-5] The result from this study also supported studies that found no significant differences when a standardized ACS exam, instead of teacher-prepared exams, was used to measure students' performance in chemistry.[5-6] The results also revealed that a percentage of clicker or online homework students than lecture-only students completed general chemistry II the following fall semester after having completed general chemistry I course in the previous spring semester. This work suggests that treatments that enhance student's feedback may increase student retention in the course sequence with no loss in learning.

Online Homework Systems (OWL Versus Webassign) versus No Graded Homework or No Online Homework on Students' Performance

The use of an online homework system was found to significantly improve students' performance on general chemistry I final exam common questions, when two general chemistry I classes taught by two similar instructors: one using online homework and the other using no graded homework were compared. This result prompted us to further investigate whether this positive effect of online homework persisted when multiple general chemistry I classes taught by the same instructor.

A single instructor taught general chemistry I classes across five fall semesters using one of two online homework systems (WebAssign or OWL) or no online homework and gave the same final exam for all the groups. The results indicated that the use of an online homework system was as effective as no online homework in improving students' performance on general chemistry I final exam. We noted that the statistically significant difference between the performance of students who used online homework and those who used no graded homework was lost when same instructor taught all the groups. This suggests that the positive effect of online homework on students' performance observed, when multiple instructors taught the course, might be confounded by instructor effects; regardless their similarity in many aspects.

The results from this study also revealed that students who used OWL for general chemistry I course significantly outperformed those who used WebAssign online homework system. This suggests that the type of online homework systems used for general chemistry I course can impact students' performance. One possible explanation that OWL was better for students' performance than WebAssign is because of OWL's mastery learning approach, helpful step-by-step tutorials, simulations, or interactive visual exercises. In general, online homework was found to be either more beneficial than, or at least as effective as, no graded homework or no online homework. This is in agreement with the body of literature related to the effect of online homework on students' performance.[7-10]

Students' Attitudes toward the Use of Online Homework

The student's gender and self-reported GPA were significantly correlated with one of the perceived benefits of online homework while their classification in school or maturity[11] as a student were not associated with any of the perceived benefits. Additionally, responses from the open-ended question pointed out that students valued the fact that online homework provided immediate feedback on the accuracy of their answers and helpful tutorials on homework related materials.

Implications for Instructors

This study found no negative effect on students' learning as result of using clickers or online homework inside or outside general chemistry I classrooms. However, when instructors consider adopting online homework systems into their courses, they need to thoroughly assess the various features of the online homework systems since the type of the systems may impact students' performance in the course differently. Instructors also need to understand that assigning homework or suggested problems by itself does not necessarily guarantee student learning unless they are followed by immediate corrective and diagnostic feedback, which helps students succeed in the course.

Future Research Directions

Future studies should replicate the effect of clickers versus online homework on students' long-term content retention using large sample sizes and incorporating a single instructor with multiple sections. Researchers should also consider investigating students'

and instructors' attitudes toward using online homework to determine how their perceptions are related to one another and how they might impact students' learning.

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APPENDICES

Appendix A: IRB Approval

April 29, 2009

Misganaw T. Gebru
mtg2p@mtsu.edu
Project Title: "The Role of Online Homework on Student Achievement in General Chemistry"
Protocol Number: 09-258

Misganaw Gebru,

As a representative of the MTSU Institutional Review Board, I have reviewed your research proposal, and determined that the study poses minimal risk to participants and qualifies for an expedited review under 45 CFR 46.110 and 21 CFR 56.110.

Approval is granted for one (1) year from the date of this letter for 2,000 participants. (Approval for projects is valid for one year only. You may need to request a continuation of approval on a yearly basis for two additional years until your project has been completed. After three years, the project must be resubmitted.)

Any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918.

According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to provide a certificate of training to the Office of Compliance. If you add researchers to an approved project, please forward an updated list of researchers and their certificates of training to the Office of Compliance before they begin to work on the project.

Please note that any change to the protocol must be submitted to the IRB before implementing this change. You will need to submit an end-of-project report to the Office of Compliance upon completion of your research.

Sincerely,
Robert Rogers, Ph.D.
Member, MTSU Institutional Review Board

From: Jerome Lacour
Sent: Monday, September 20, 2010 11:00:12 PM (GMT-06:00) Central Time (US & Canada)
To: Misganaw T. Gebru
Subject: RE: Permission to Reprint

Dear Misganaw,

Of course.

Thanks for inquiring,
With best wishes
Jerome Lacour

-----Original Message-----
From: Misganaw T. Gebru [mailto:mtg2p@mtmail.mtsu.edu]
Sent: lundi 20 septembre 2010 22:39
To: jerome.lacour@unige.ch
Subject: Permission to Reprint

Dear Professor Jerome,

I am a doctoral student in chemistry at Middle Tennessee State University working under the supervision of Professor Gary Wulfsberg. I am currently writing an article on aqueous syntheses of Group 1 Metal TRISPHAT salts to be published on *Inorganica Chimica Acta.*

Would you grant me permission to reprint the figure of the TRISPHAT enantiomers found in the abstract for "F. Favarger, C. Goujon-Ginglinger, D. Monchaud, J. Lacour, *J. Org. Chem.* 69 (2004) 8521-8524" both in my dissertation and the paper I am preparing?

Thank you for your help.
Sincerely,

Misganaw Gebru
Department of Chemistry
Middle Tennessee State University

Appendix B: Survey Questions (Fall 2009, Spring 2010, and Fall 2010)

The Role of Online Homework on Student Achievement in General Chemistry

Investigator: Mieganaw Gebru

Mieganaw Gebru, graduate student of Middle Tennessee State University Department of Chemistry, is conducting a research project on the role of online homework on student performance in General Chemistry. To do this, I will ask you to complete online survey about demographics, prior achievement, attitude toward online homework and some general questions on homework. To examine the impact of online homework and attitude toward online homework on student achievement in General Chemistry, I will collect scores on online homework and final exam. I will also perform a comparison of student performance in General Chemistry with and without online homework. I expect the online survey to take approximately 15 minutes of your time.

Responses on the online survey and scores on the online homework and the final exam will be stored in a secured location. Only Mieganaw will have access to the collected document. All information you give to me is strictly confidential. Your privacy will be carefully protected in any reports of the findings of this project. No risks or bad effects are expected to occur as a result of taking part in this research at any time. If you choose to withdraw later or to not participate now, there will be no consequences for you.

By being a participant in this research, you will make a major contribution to the better understanding of the role of online homework on student achievement in General Chemistry.

This form is an indication of your voluntary agreement to take part in this study. If you have any questions or concerns, either now or later, please feel free to ask or articulate them. You may have a copy of this consent form if you wish. You may also contact Mieganaw at 615-738-8149 or Dr. Phelps (Faculty advisor) at 615- 898-2077 about the project or Middle Tennessee State University's Office of Compliance - Human Subjects in Research at 615 898-8918 with any complaints or problems with regards to this project or about your rights as a study participant.

Your agreement to this consent form means that you understand the information presented, and that you want to participate in the study. You understand that participation is voluntary, and you are free to withdraw consent and discontinue participation at any time.

***1. Do you agree to the consent information stated on the above form?**

- ◯ Yes, I agree to the above consent form.
- ◯ No, I do not agree to the above consent form.

[redacted]

Please answer the following questions.

*2. Please write your full name (first & last names) and your section (next to the course you are taking).

Full Name [redacted]

CHEM 1110; Section [redacted]

CHEM 1120; Section [redacted]

3. How old are you?

○ 18 - 20 ○ 21 - 23 ○ 24 - 26 ○ 27 - 30 ○ 31 - 33 ○ 34 - 36 ○ 37 - 39 ○ > 39

4. What is your Gender?

○ Female ○ Male

5. What is your Major?

○ Biology ○ Chemistry ○ Engineering Technology ○ Nursing ○ Undeclared

Other (please specify) [redacted]

6. What is your student classification in University?

○ Freshman ○ Sophomore ○ Junior ○ Senior ○ Graduate

7. What is your current GPA?

○ 1.99 or less ○ 2.00 - 2.49 ○ 2.50 - 2.99 ○ 3.00 - 3.49 ○ 3.50 - 4.00

8. What grade do you expect to receive in this class (CHEM 1110 and/or CHEM 1120)?

○ A ○ B ○ C ○ D ○ F ○ I do not know.

9. Did you take General Chemistry (CHEM 1110 and/or CHEM 1120) course before?

○ Yes ○ No

If Yes, please specify (CHEM 1110 and/or CHEM 1120) [redacted]

10. What grade did you receive? (SKIP THIS QUESTION IF YOUR ANSWER FOR Q.# 9 IS 'No')

○ A ○ B ○ C ○ D ○ F ○ Other

[redacted]

11. Are you repeating General Chemistry (CHEM 1110 and/or CHEM 1120) course?

○ Yes ○ No

If Yes, Which one (CHEM 1110 and/or CHEM 1120)? and Why?

[redacted]

12. How many total credit hours are you currently taking?

[redacted]

[redacted]

Please answer the following general questions about homework.

13. Please select one of the five choices that is relatively best response for each of the following questions.

	Almost never	Sometimes	At least half of the time	Most of the time	All of the time
[redacted]					
Is your homework graded?					
[redacted]					
Do you think that people who do homework are more successful in class than those who do not?					
[redacted]					
Do you do problems beyond the assigned problems?					
[redacted]					

14. How many hours would you say you spend on homework for this class in a week?

◯ Up to 1 hour in a week ◯ 2 - 4 hours in a week ◯ 5 - 10 hours in a week ◯ 10+ hours in a week

15. How much time (minutes/hours) do you think homework should take for a college Chemistry course in a week?

[redacted]

Please answer the following questions about online homework.

16. Does your General Chemistry class have online homework?

○ Yes ○ No

17. Please select one of the choices that best describes your experience with online homework.
(SKIP THIS QUESTION IF YOUR ANSWER FOR Q.# 16 IS "No")

	Almost never	Sometimes	At least half of the time	Most of the time	All of the time
	○	○	○	○	○

18. Do you use OWL (Online Web-based Learning) to do General Chemistry homework in your classes?
(SKIP THIS QUESTION IF YOUR ANSWER FOR Q.# 16 IS "No")

○ Yes ○ No

Please specify if you use other online homework systems other than OWL

19. Have you ever sought out help with your homework (online or otherwise)?

○ Yes ○ No

20. If your response is "Yes" for the above question(Q. # 19), please answer the following questions.

	Almost never	Sometimes	At least half of the time	Most of the time	All of the time
How often have you sought help from a chemistry tutor?	○	○	○	○	○
How often have you sought help from a family member who is good at chemistry?	○	○	○	○	○
How often have you sought help from another professor or teacher?	○	○	○	○	○

[redacted]

21. If [redacted] is defined as anything you do outside of laboratory or class, what type of homework do you believe is more effective?

○ Traditional paper-based homework ○ Web-based homework (Online homework)

Why?

[redacted]

The Role of Online Homework on Student Achievement in General Chemistry

Investigator: Misganaw Gebru

Misganaw Gebru, graduate student of Middle Tennessee State University Department of Chemistry, is conducting a research project on the role of online homework on student performance in General Chemistry. To do this, I will ask you to complete online survey about demographics, prior achievement, attitude toward online homework and some general questions on homework. To examine the impact of online homework and attitude toward online homework on student achievement in General Chemistry, I will collect scores on online homework and final exam. I will also perform a comparison of student performance in General Chemistry with and without online homework. I expect the online survey to take approximately 15 minutes of your time.

Responses on the online survey and scores on the online homework and the final exam will be stored in a secured location. Only Misganaw will have access to the collected document. All information you give to me is strictly confidential. Your privacy will be carefully protected in any reports of the findings of this project. No risks or bad effects are expected to occur as a result of taking part in this research at any time. If you choose to withdraw later or to not participate now, there will be no consequences for you.

By being a participant in this research, you will make a major contribution to the better understanding of the role of online homework on student achievement in General Chemistry.

This form is an indication of your voluntary agreement to take part in this study. If you have any questions or concerns, either now or later, please feel free to ask or articulate them. You may have a copy of this consent form if you wish. You may also contact Misganaw at 615-738-6149 or Dr. Phelps (Faculty advisor) at 615- [illegible]2077 about the project or Middle Tennessee State University's Office of Compliance - Human Subjects in Research at 615 898-8918 with any complaints or problems with regards to this project or about your rights as a study participant.

Your agreement to this consent form means that you understand the information presented, and that you want to participate in the study. You understand that participation is voluntary, and you are free to withdraw consent and discontinue participation at any time.

***1. Do you agree to the consent information stated on the above form?**

- ◯ Yes, I agree to the above consent form.
- ◯ No, I do not agree to the above consent form.

Please answer the following questions.

*2. Please write your full name (first & last names) and your section (next to the course you are currently taking).

Full Name [redacted]

CHEM 1110; Section [redacted]

CHEM 1120; Section [redacted]

3. How old are you?

○ 18 - 20 ○ 21 - 23 ○ 24 - 26 ○ 27 - 30 ○ 31 - 33 ○ 34 - 36 ○ 37 - 39 ○ > 39

4. What is your Gender?

○ Female ○ Male

5. What is your Major?

○ Biology ○ Chemistry ○ Engineering Technology ○ Nursing ○ Undeclared

Other (please specify) [redacted]

6. What is your student classification in University?

○ Freshman ○ Sophomore ○ Junior ○ Senior ○ Graduate

7. What is your current GPA?

○ 1.99 or less ○ 2.00 - 2.49 ○ 2.50 - 2.99 ○ 3.00 - 3.49 ○ 3.50 - 4.00

8. What grade do you expect to receive in this class (CHEM 1110 and/or CHEM 1120)?

○ A ○ B ○ C ○ D ○ F ○ I do not know.

9. Did you take General Chemistry (CHEM 1110 and/or CHEM 1120) course before?

○ Yes ○ No

If Yes, please specify (CHEM 1110 and/or CHEM 1120) [redacted]

10. What grade did you receive? (SKIP THIS QUESTION IF YOUR ANSWER FOR Q.# 9 IS 'No')

○ A ○ B ○ C ○ D ○ F ○ Other

11. Are you repeating General Chemistry (CHEM 1110 and/or CHEM 1120) course?

○ Yes ○ No

If Yes, Which one (CHEM 1110 and/or CHEM 1120)? and Why?

12. (For CHEM 1120 STUDENTS ONLY) With whom and when did you have CHEM 1110?

Name of Professor Semester

13. How many total credit hours are you currently taking?

Please answer the following general questions about homework.

14. Please select one of the five choices that is relatively best response for each of the following questions.

	Almost never	Sometimes	At least half of the time	Most of the time	All of the time
[redacted]					
Is your homework graded?					
[redacted]					
Do you think that people who do homework are more successful in class than those who do not?					
[redacted]					
Do you do problems beyond the assigned problems?					
[redacted]					

15. How many hours would you say you spend on homework for this class in a week?

Up to 1 hour in a week | 2 - 4 hours in a week | 5 - 10 hours in a week | 10+ hours in a week

16. How much time (minutes/hours) do you think homework should take for a college Chemistry course in a week?

[redacted]

Please answer the following questions about online homework.

17. Does your General Chemistry class have online homework?

○ Yes ○ No

18. Please select one of the choices that best describes your experience with online homework.

(SKIP THIS QUESTION IF YOUR ANSWER FOR Q.# 17 IS 'No')

	Almost never	Sometimes	At least half of the time	Most of the time	All of the time
	○	○	○	○	○
Online homework helped me prepare for tests.	○	○	○	○	○
	○	○	○	○	○
HelpAd feedback was provided by the online homework system.	○	○	○	○	○
	○	○	○	○	○

19. Do you use OWL (Online Web-based Learning) to do General Chemistry homework in your classes?

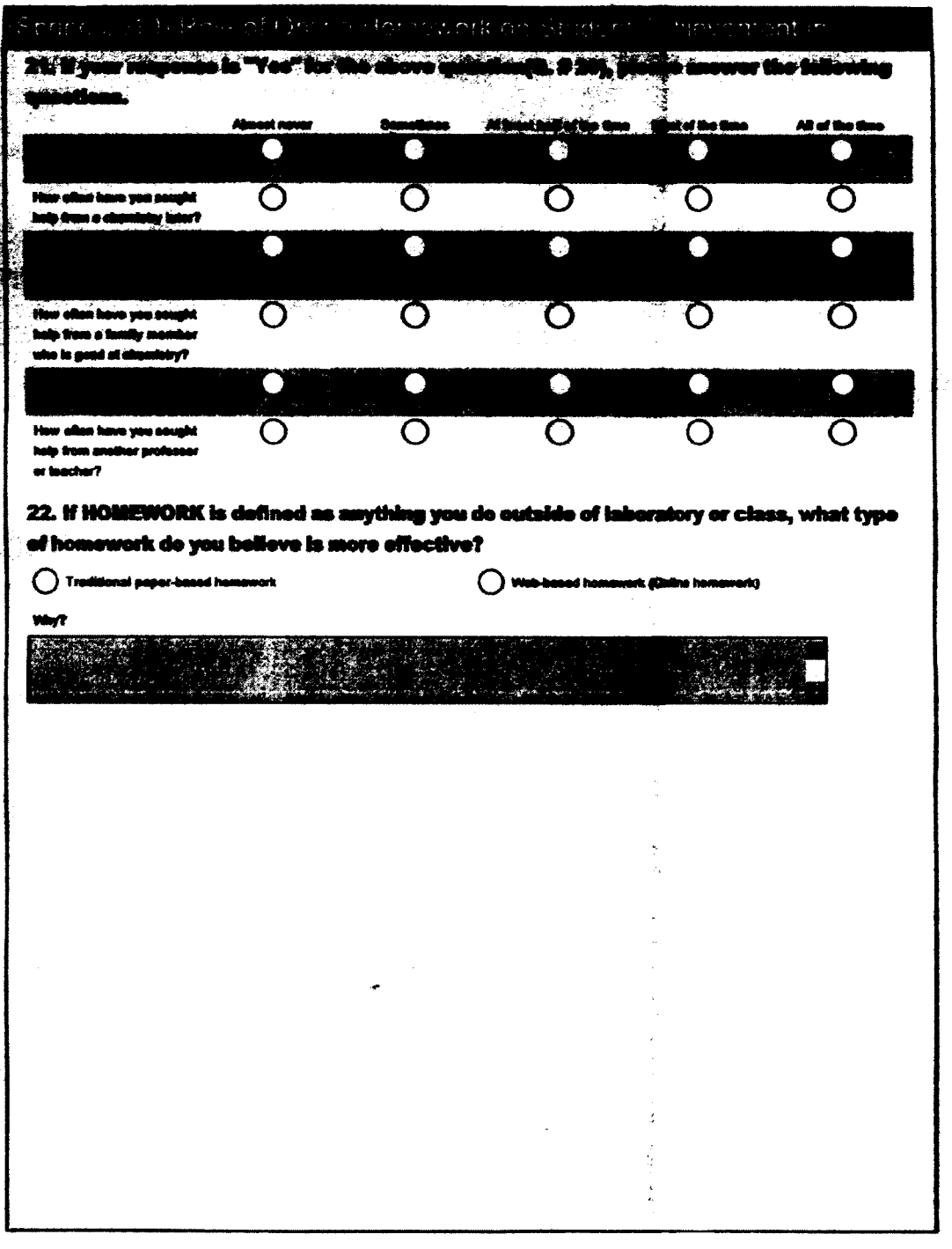
(SKIP THIS QUESTION IF YOUR ANSWER FOR Q.# 17 IS 'No')

○ Yes ○ No

Please specify if you use other online homework systems other than OWL.

20. Have you ever sought out help with your homework (online or otherwise)?

○ Yes ○ No



21. If your response is "Yes" for the above question, i.e. Q 20, please answer the following questions.

	Almost never	Sometimes	About half of the time	Most of the time	All of the time
[redacted]	○	○	○	○	○
How often have you sought help from a chemistry tutor?	○	○	○	○	○
[redacted]	○	○	○	○	○
How often have you sought help from a family member who is good at chemistry?	○	○	○	○	○
[redacted]	○	○	○	○	○
How often have you sought help from another professor or teacher?	○	○	○	○	○

22. If HOMEWORK is defined as anything you do outside of laboratory or class, what type of homework do you believe is more effective?

○ Traditional paper-based homework ○ Web-based homework (Online homework)

Why?

[redacted]

Appendix C: Students' Full Written Responses to Open-ended questions (Fall 2009, Spring 2010, and Fall 2010)

Fall 2009

F09/001.	you have to work alot of the problems out on paper anyways, even with web based hw. so you might as well have something to do with the paper like turn it in. also its easier for someone that is helping you to find your mistakes with paper homework, instead of just looking at your answer wondering how you got it
F09/002.	people are more inclined to sit down at a computer to do work
F09/003.	paperless is more cost effective for the stundent. From previous web-based homework classes, homework causes more interaction with the notes and text from the class(in my opinion).
F09/004.	it feels to me that doing things the old way gives the basics
F09/005.	One can carry the traditional homework around and work on it with a computer or without; web-based homework is limited to using a computer.
F09/006.	If you are stuck on a problem, the web-based homework is designed to help you.
F09/007.	Web-based homework is more practical. If we had to do all those problems on paper [Instructor's name] would not have had time to grade all that for 200+ students. It makes more sense to have it online (although the OWL system could be frustrating at times) and just ask for help if we need it. It also gives us the flexibility to do it when we want to and turn it in any time before the due date. I also like that we get to try problems multiple times and the corrections are automatic, so we can look at a problem and do it until we get the correct answer. You can't do that with traditional paper-based homework.
F09/008.	There is not as much pressure to get the correct answer. With web-based homework, at least with Webassign, each student only gets two opportunities to get the right answer. If you are wrong, it does not explain what you did, how to do it correctly, or give partial credit. Sometimes, the problems on webassign were things we hadnt even talked about in class, and since no one knew how do to them, everyone lost points.
F09/009.	Privacy reasons.. I've used several types of online learning tools, and I'm a

	computer science student.. A lot of the learning utilities are corporate controlled, and I don't believe we need any more corporate control over learning.. I may be a bit philosophical, but education shouldn't be ran for business profits, it should be socialized properly, rather than costs being socialized and profits being privatized.. I can't stand D2L, and other teaching tools developed in the private sector tend to be quirky and inadequate in my opinion.
F09/010.	If you have problems with it there is always a tutorial.
F09/011.	If it is online then the technology is more advanced and the questions and answers might seem more 'modern' than just working straight out of a book, which might seem 'old school'
F09/012.	Actually both. The paper method helps for extra work. The down side to that is you don't know if you have the correct answer immediately. The web-based homework is great for knowing if it is correct, but the paper method is more "hands on".
F09/013.	I had a hard time with the online homework I felt it took entirely too long to complete which took away from valuable study time. I also felt that owl is too case sensitive and small mistake will count a whole problem wrong. I was very disappointed with the owl homework. I didn't like doing my homework online at all, and I know alot of others who I spoke with in my class felt the same way.
F09/014.	If you answer incorrectly they give you a tutorial to help you understand what you did wrong.
F09/015.	I have to be honest, I am 32 yrs old with outside repsosibilities and doing online work is not always feesible as I can't always get to a computer. But I think both hold the same amount of effectiveness. I do like being able to access the "thinkwell" videos that were available.
F09/016.	While I think the homework problems in the book help, the internet homework has the potential to have more varied types of question. Working problems multiple ways would help me to better learn a concept I believe.
F09/017.	if there is a problem, you know immedieatly
F09/018.	You can actually write out the steps, and work it out slowly.

F09/019.	because it had tutorials to help you understand the problem if you didnt get it right the first time.
F09/020.	Because it will tell you when you are wrong and it shows you how to do the problem correctly.
F09/021.	i feel like i learn better if i can write the steps out and figure it out myself. but the online homework was helpful because it showed us how to do the problems as well.
F09/022.	shows you whats wrong
F09/023.	I believe that problems that requires reading from the book would help more because you're gaining more knowledge by reading and finding the answer while online is just focus on that one problem.
F09/024.	Paper-based homework forces me to work out the problems thoroughly.
F09/025.	I still prefer traditional homework. The online homework can be very helpful, but it still is not perfect. Often times there are glitches in the system which are very annoying. Also when you come up with the wrong answer, the hints it gives you are not always very helpful. overall online homework is nice and convient, but it still has its flaws.
F09/026.	because online homework usually has a "help" function that will almost do the whole problem for you, and there's no help function on an exam.
F09/027.	because it has tutorials in case if you get it wrong and it shows how to do it the right way
F09/028.	It is difficult to type the correct answer online.
F09/029.	It can be accessed, submitted, and reviewed at any time. Paper based is a hassle and can be vague.
F09/030.	because it helps me and if i get it wrong i can find the answer.
F09/031.	Because you are physically writing down the answers.
F09/032.	Honestly, I like them both. They both have their pros and cons. The reason I chose the web based is because it gives you the right answer, so you can know

	if you are doing it right or not. Also, it has the step by step tutoring thing if your answer is wrong.
F09/033.	Easier to take to professors or tutors to ask questions. Also it is easier to take with you to do in your down time at school, work ect.
F09/034.	When you answer questions online you have to be absolutely correct for instance if you put like ml instead of mL then you were count wrong. I really did not like how i was checked and graded using the OWL program.
F09/035.	the online hw will only be effective if the professor is in sync with the hw, they know the paper hw and it is effective when used properly and taken seriously
F09/036.	Because the tutorials helped me to understand what I was doing wrong and helped to guide me to the correct answer and that is not possible the traditional paper/pencil way.
F09/037.	because it helps you know if you are doing the problems correct and if you aren't then it shows you step by step how to do it correctly.
F09/038.	you actually have to sit down and totally focus on your homework. It is also harder to cheat on homework that is supposed to be done for a grade if it is on paper rather than if it is online.
F09/039.	because the owl shows you steps to do the problems and im on the computer all the time anyways so its just more convenient
F09/040.	Some people are not able to afford to purchase expensive sign in "codes" or purchase new books from the bookstore. I happened to be one of those people this semester.
F09/041.	Because if you are doing the problem wrong the online hw will guide you through it so you can get it right
F09/042.	because if you don't understand the question there are usually tutorials that will explain it and they are easier to understand then a chemistry book
F09/043.	b/c it gives the tutorials to help you if you put in the wrong answer. It is very similar to having your teacher at home helping you with your homework.
F09/044.	I enjoyed using the OWL system more than traditional homework. You are

	able to get help more easily and you get instant feedback on your answers as well as help from the system to immediately correct your mistakes and gain a better understanding for what you did wrong.
F09/045.	In OWL it teaches you the steps you need to take in order to get the problem correct and that is very helpful. I do not think written homework is effective. It causes more isssues.
F09/046.	I enjoy working the problems on paper better. Helps me to remember how to do it on a test.
F09/047.	Because you are forced to look at it and sit down and write out the problems. Most of the time there is online tutorials as well that aid in the help of doing the homework.
F09/048.	It takes less time
F09/049.	Because once you get something wron it comes up with helps tutorials
F09/050.	ONLINE HOMEWORK CAN GIVE YOU FASTER FEEDBACK
F09/051.	Because it helps you do the actual work and shows the step to do it if you don't know how to do it.
F09/052.	it explained the problems very well...and took me step by step
F09/053.	It's more effective because it tells you what you do wrong and how to correct it. It's like a tutor.
F09/054.	Because online homework is hard to acsess and work out. The computer does not take parcial credit and will mark answers wrong that are spelled incorrectly even if the student has answered the question correctly. It is a lot of nonsence and very little learning.
F09/055.	i'm a visual learner and have the visual tutuorials are really helpful. exp for the electron orbitals...I really like OWL
F09/056.	You have it at all times and you dont have to depend on a computer
F09/057.	Its more interactive. When you get a question wrong it takes you through each individual step which was very helpful

F09/058. if you get the question wrong it will tell you why and help you!

F09/059. I feel it is more related to what the professor wants you to learn.

F09/060. because it when you write what you are thinking you tend to understand and comprehend it better. I think Online home work is a wast of time because why am i paying a teach to teach in a lecture class to teach me. Plus with this program i got frustrated many time because of how owl wanted the answer formated even though i knew the correct answer. If you plan to take an online class then take an online class, but if you sign up for a lecture class then homework should be in class not out of class.

F09/061. Because it helps you understand what you're doing wrong if you miss the question, where as with traditional paper-based homework you just kind of have to guess whether what you're doing is right or wrong, plus if you continue to do all of the problems wrong that's not helping at all.

F09/062. because you have to write out the equations and it is easier to see what you are doing and what you need to do.

F09/063. Allows for easy access and standardized assistance with problems. The step-through process of the OWL program was very helpful on concepts I didn't understand

F09/064. Because it helps you with the right answer, and helps you understand what you did wrong and why.

F09/065. There are different ways to do it, the student will not become as bored as easily as with the tedious and redundant paper based homweork

F09/066. because the online homework helps you with problems you cant figure out, whereas with paper homework you have to go to a tutor to get that same help

F09/067. Web-based, because it gives you a variety of problems to work out and it helps you work out a problem step-by-step if you get stuck.

F09/068. Because if you miss the problem, it breaksthe problem down and shows you how the do it.

F09/069. its more interactive, and if you don't know how to do something it helps you step by step

F09/070. I really struggled with the online material because it was harder for me to be able to write out and literally visualize the problems. I even have my own white board, but it was difficult because I did not know if I was doing it correctly. After failing numerous times and spending hours on homework, I finally got discouraged and stopped doing it. OWL was particularly difficult for me because I often did not know how the system wanted the answers formatted, or for particular problems I did not understand how to type out the answers in a way that the program would recognize it as a right answer. It was not very user friendly, and I often got frustrated very quickly and spent more time trying to figure out the system and how it wanted me to answer the questions, rather than learning the material. I did not enjoy my experience with this particular online-based homework program.

F09/071. If the web site crashes, students will not be able to complete their homework. However, a textbook is always available.

F09/072. Because if you use web-based, there are so many technical problems that can occur and you can be counted off for. Traditional based problems don't have that problem. In this particular class, there are so many online problems that any person with a family and full-time job just can't do, there isn't enough time in the week. Also, the instructor isn't the one grading the homework so they don't know who is having problems or what material isn't being understood.

F09/073. Easier to work out problems and see where you make a mistake. Also, partial credit can be given and it is harder to cheat if it is paper-based.

F09/074. well, we are not assigned any homework in my chemistry class. all we have are four exams, the professor's handwriting is slopping and that is all the teaching we receive is in the form of his handwriting. he is very difficult to understand. and when he gives us an extra credit assignment for the test because the average grade is a 50, his assignments are very difficult. there is no homework in this class. if we used owl like other chemistry classes to practice material that we are supposed to learn in class, it would help us make better grades on the exams.

F09/075. With web-based homework one receives feedback almost immediately. While web-based homework is VERY inconvenient, that one aspect makes it worth its weight in gold. Furthermore, if one has completed all of the problems and wishes to do more to ensure understanding, the problems will be based on the same content but they will be different allowing a complete understanding of the concept rather than one specific problem. This is an impossibility with traditional paper-based homework.

F09/076. The online owl homework confined me to my lab station. It had many malfunctions and one small slip would caused you to do the whole thing over again. Paper based allows me to conveniently travel and do homework wherever i please. That allows me to have the desire to work on it when it has became more accessible

F09/077. too many technical problems with online homework. A lot of complaints regarding notations, writing out formulas, and sometimes poor instructions. Plus writing plays a huge psychological impact on comprehending the material at hand. People tend to remember more of what they write then what they type.

F09/078. Web-based homework is tedious and annoying. I can't stand having to put in all the little characters for subscripts and superscripts. I've never had a web-based assignment that was worth my time. It really frustrates me.

F09/079. There are many options to get help and explanations right there without having to schedule an appointment with a tutor or a workshop.

F09/080. I really can't say since I have yet to have a class at MTSU that uses wed-based homework. My son is an engineering student at Lipscomb University and has web-based homework in most of his classes. He thinks it is very helpful.

F09/081. I think it's less confusing. More easier to work out and explain, in a way than the web.

F09/082. I used other school website for online homework

F09/083. Because there is oftentimes an explanation with the answers that are provided yielding better understanding.

F09/084. because you don't have to worry about if you are going to have internet connections or not, you don't have to worry how many times you get to try it, and most importantly it follows the book and the book give examples.

F09/085. Because you can actually see what you are doing. In Chem 1110 we had online homework, which was difficult to enter in correctly, and you were counted off because of entering in mistakes versuses the actual answer and work itself.

F09/086. B/c the teacher does not provide the right answer online if your answer is incorrect

F09/087. I can see exactly what i am doing correct or wrong

F09/088. online work is hard on the eyes after a while. The OWL system still has kinks which professors donot give credit for. For example, the answer put in is the right answer per the given solution when problem counted wrong. Also differences between the way the teacher teaches the material. what is right in class is not right on OWL.

F09/089. I think physically writing down information and working out problems, helps with comprehenstion.

F09/090. It makes you write everything out and focus on what you need to do, and it is in the same general format as the test/final.

F09/091. i am a hand-on person, so online homework was more difficult. Also, there were more ways to make simple technical errors that normally would not have been counted against you.

F09/092. Writing things down helps the information stick in your memory.

F09/093. Although the online homework helps, I feel that paper is much better because your professor is actually involved and knows where you stand. They can give you accurate feedback and explain the exact answer to your question. Sometimes, I have spent about 3 hours on one assignment on OWL that I did not understand the feedback, and then asked my teacher and understood in 5 minutes. I like that there are assignments available online, I just wish that they were graded and given feedback on by the professor.I feel that that would be much more beneficial.

F09/094. i feel that i am more likely to concentrate and actually do the work whole heartedly online whereas paper based i would probably do while doing other things as well.

F09/095. It is more hands on, and you take the test on paper so people will do better on paper tests if they are doing homework on paper.

F09/096. online is easier to forget

F09/097. Used to it. Online has to use either multiple choice answers or a system that is probably strict about rounding (ex. My answer: 2.57; Computer: 2.8) Might mark it wrong when the answer is within an acceptable margin of error. Paper allows for notes and figures that might help a student remember things about a type of problem.

F09/098. gives more tries to answer the problem.

F09/099. cause I'll do it

F09/100. The Owl homework is frustrating because if you push the wrong button it will count your problem as wrong of take you to the next page and you are unable to put the correct answer even when you know the correct answer. I would much prefer paper homework, because that is how you would complete it on a test.

F09/101. It is convenient and can be helpful with tips and clues that show you how to do some of the problems. The examples are also clearer than what is sometimes put in textbooks.

F09/102. Because computers can not work correctly at times

F09/103. Because with online homework, I have to go to a computer. With paper homework, I can do it whenever

F09/104. It is more convenient and environment friendly. I enjoy it more than the traditional paper-based homework. It is also easier on the professor because there are less papers for them to grade, as it is all done electronically.

F09/105. I think it just depends on your learning style. I have never tried online homework so I do not know if it works for me.

F09/106. It's easier for instructors to provide links to additional resources that are often visually/aurally stimulating. This is valuable when trying to learn any subject. Traditional homework based on textbooks rely on reading alone.

F09/107. It is just more concrete.You can take the work sheet to a tutor for help instead of having to sign on copy down the problems and whatnot.

F09/108. immediate right/wrong response and helpful hints to get the right answer

F09/109. I am not a fan of trying to do chemistry on a keyboard.

F09/110. Professors can actually track your status, unlike paper homework when they rarely check it. Web-based makes you feel like you must do it.

F09/111. I think that it tends to make more sense if you work in out on paper

F09/112. traditional paper-based homework that is turned in to be graded allows professors to see more than just the answer if there is work to be shown. This allows them to see where students are making mistakes. In addition, online homework may require an answer in one format, but a correct answer may be given in a different format, and thus the problem may be counted wrong. Finally, computer glitches, viruses, complications, and other imperfections, make online homework less effective than traditional paper-based work.

F09/113. gives you the ability to work out a problem several times and writing it down helps a lot because you can remember things better and visualize it.

F09/114. It explains how to correct the problem instantaneously. That helps alot faster :)

F09/115. Get to write down the equations.

F09/116. They give you the answer and walk you through the question if you are having trouble.

F09/117. The web based homework is decent at teaching, but is definitely not comparable to working problems in the traditional manner. Having te daily feedback of normal homework is much more effective at reinforcing the lecture than is the homework that can all be done the night before a test.

F09/118. because it is less paper work for the teacher. and you can almost instantly know your grades

F09/119. both are good and i think the more you actually work out by hand the better you get.

F09/120. For me it's so much easier to access, and the way OWL is designed when you get a question wrong it takes you through the steps. This was a tremendous help to me! I'd even go back and look over the hw before my tests.

F09/121. online homework is too rigid.

F09/122. if it is a good web based it should have tutorials

F09/123. I found it frustrating using OWL due to technical difficulties. I did not understand sometimes on how they wanted me to type something in or things wouldn't register. I did not like using online homework

F09/124.	More easily accessible.
F09/125.	because sometimes with online homework you can guess and get the right answer and end up not learning anything.
F09/126.	That's the only homework I've ever had so I don't know how effective online homework would be.
F09/127.	It helps to write things out to be able to understand the concepts and the math. Writing things down for me really makes sure that I know what I'm doing. However, the online homework was helpful because when you got something wrong, it offered a tutorial that could help you find out what you had done wrong.

Spring 2010

S10/001.	becuase online homework doesn't always require you to work it out. Online homework sometimes gives you the answers and you don'tl earn anything.
S10/002.	The online homework has helpful tools that help you work through each problem step by step.
S10/003.	Online homework must be entered in too specifically
S10/004.	some of the online homework did not match the material we were learning in the classroom
S10/005.	I have no real opinion other than the format of the homework should match the format of the test.
S10/006.	Web-based homework is easier for the teacher to grade. Paperless homework is more economical. The OWL homework program has helpful hints along the way, although I frequently felt I was clicking until the program essentially gave me the answer in order to meet the deadline. There's some sort of value, though, connected to traditional paper-based homework and referencing the text from which we are not able to benefit.
S10/007.	I helped my sister with some of her online chem homework and frankly it was harder because you must put answer in actually or its wrong (formating issues) it would be better if it was mutiple choice, but prefer not to have

	online homework. I have had online homework for other classes such as economics but would prefer not to have online work.
S10/008.	I think that both are helpful because the tests are mostly based off of the book that paper-based homework would come from. However, the online homework is helpful because you instantly know if you are right or wrong and the OWL program offers hints if you've made a mistake.
S10/009.	Because the online homework was a waste of time and money for me. Most of the time it was due before we talked about it in class so I ended up just doing it to get points. It didn't not help me at all.
S10/010.	i remember things better when i write them down
S10/011.	Because you can take the problem on a sheet of paper anywhere to get help without requiring access to a computer or internet... Paper homework also makes it easier to go over in class or with a teacher outside of class.. Paper homework allows you to bring the problem into class and work out your mistakes while the teacher is going over that specific concept...
S10/012.	The web-based homework basically gave you the answer when you typed a dumb answer in. It did not help me study at all, and I did not learn much from the online homework.
S10/013.	Both are helpful, but the online homework will help you solve the problem and give you examples without the trouble of trying to find examples in the book or other places.
S10/014.	it tells me when i'm wrong and tells me how to correct it
S10/015.	Because there is feedback and you have to get the problem right before you are able to proceed. Plus it is a lot more conveinent.
S10/016.	I find it much more effective to write out and work problems on paper. I would not like online homework because there is always a difference in the way your teacher explains and veiws something and the way the person writing the homework does. We already see this in our Chemistry lab there were quite a few differences in [Instructor's name]'s wording and methods and my Chemistry professor.
S10/017.	The tutorial and knowing for sure if you answered right or wrong.

S10/018.	it gives you immediate feedback
S10/019.	The OWL website can help you go through the problems if you get stuck.
S10/020.	OWL had a lot of errors with the program and it would accept incorrect answers as correct and it would not accept correct answers also. Also the OWL program was more about how you input your answer, it was difficult to understand how the computer wanted you to express your answer.
S10/021.	you learn more
S10/022.	With Owl, most students just typed in a wrong answer and then followed the steps to get the right answer and never absorbed anything.
S10/023.	I learn it better if i see it written rather than online
S10/024.	You can take it to class with you and go over it.
S10/025.	Online homework shows examples done in a procedure done differently than in class by the professor. If the class teaching coordinated with the homework online it would be nice, but it does not. Sometimes it was helpful doing the online homework but more so it was annoying. If you get one step of a problem wrong you get it all wrong and then you have to do a whole new problem instead of getting the chance to figure out the same one. Sometimes I would spend 1 hour on one section of homework because I had to do new problems every time and do the same steps I already had to do. With paper homework you can try and try again until it is right.
S10/026.	I understand better writing the problems out.
S10/027.	It is easier to understand when you write it yourself. Typing it doesn't have the same effect and is much harder to remember, and the computer is often very picky about how you write it, even if you have the correct answer and that is very frustrating.
S10/028.	The Web homoework never relates to anything we have on the test. Last semester [Instructor's name] used traditional homework and all of that information would then be on the test. It was much more effective.
S10/029.	I think the paper-based homework would force students into learning the material instead of just expecting to gain the answer from the helpful steps provided. It would take more thought on the student's part.

S10/030.	Easy to see and write. Even though the online service is convinient, paper homework is easy to read anywhere
S10/031.	The hints helped alot. I understood some of the material, teacher would assign the homework before we would go over it. But the online hints help and the research i did as well.
S10/032.	Formatting is tricky on the online homework. Frustrating to have the right answer and NOT have the right answer because one ^ or freaking squiggly line is off. Also it's terribly easy to forget about when online homework is due.
S10/033.	Is quicker, if online homework also provide solution after completion is better.
S10/034.	because the you really need to know the material with paper-based work. the online homework can help you with hints and steps that you will not have on the test, and most people use that as a crutch
S10/035.	this way the assignment is always available to you even out side of class and you can reach other class mates easier about help
S10/036.	They are both effective in their own ways. I hated the on-line homework because it was time consuming problems trying to type the answers in 100% correct. I thought it was more stressful to do the online homework than it is to do paperbased homework. If you got to the end of the section and missed one question you had to start all over on that section to receive full credit. Many times I may have punched in one number wrong or mispelled something or hit enter by accident before I was ready. It is much easier to write chemical equations down than to type them on the homework.
S10/037.	Gives more feedback
S10/038.	I am just used to traditional paper-based homework. I feel more comfortable with it. Also there were numerous times with OWL that it would not take an answer that was correct but in a different form. For example, it would not take 4.6x10^-3 or 4.6E-3 but it would take 0.0046. It was just frustrating at times.
S10/039.	online homework just sucks, poorly explains how to do the problems
S10/040.	Its more hands on if you are doing paper-based homework. I believe that it

	sticks with you longer if you write it out. The web homework is definitely easier, but i find it more difficult to remember because you can complete it pretty quickly most of the time. With paper-based homework the professor could assign problems that relate more to what is going to be on tests. A lot of the web-based homework was not much help towards tests.
S10/041.	Because you get better feedback when it is turned in and graded.
S10/042.	It give me extra help if I did not know the answer
S10/043.	I am more likely to do online homework. In calculus I always had my online homework done, but procrastinated with my traditional homework.
S10/044.	The web-based homework would tell you how to work the problem and give you the answer, so you really didn't learn much.
S10/045.	Because personally, it is more embarrassing to have to explain face-to-face that I have no paper to hand to my professor, so I'm more likely to do it.
S10/046.	I think paper-based homework gives more opportunity to write out complete steps in problem solving.
S10/047.	The instant feedback is nice
S10/048.	You don't have the hassel of your computer not working or typing something in wrong and being counted off for something you know how to do. I have Web based homework!!!!
S10/049.	Because you have all of the work out in front of you and have to write out the process of doing it, which helps you prepare for the test. If you just do it online, you can just follow the hints until you get the answer, which does not force you to figure it out on your own (which helps you learn).
S10/050.	I can keep it on hand and nothing technical goes wrong.
S10/051.	I can see the value in using OWL, but I still think traditional paper homework is more useful. OWL has far too many bugs to actually be effective. It seems that most people spend more time being frustrated by how to actually use the system than they do successfully completing homework. It's a little disappointing that a service which costs $35 per semester has such serious problems.

S10/052. It is easier on the students

S10/053. The most aggravating part about OWL was when their system wouldn't allow you to put in the correct answer. But, I will say the best thing about OWL was that if you were completely lost, it'd show you the steps to getting the answer. However, if you didn't understand the steps to begin with (which happened to me a lot) it was pointless and frustrating.

S10/054. its graded. but i do the assigned problems as well because they do help me

S10/055. It seems like when you physically do it on paper, you tend to understand it better. It is also less confusing because you don't have to use weird notation when trying to write out exponentials and charges like you have to with the online homework.

S10/056. the paper-based homework was more relevant to out tests

S10/057. More interaction

S10/058. It is usually more specific problems for the material the teacher teaches and expects you to know for test.

S10/059. i learn by doing things, and actually working out a problem in front of me helps me learn better

S10/060. Well both are helpful to me. I purchased the Gen Chem answer book, so i benefit both from the online and paper based homework. Online homework helps me understand the material, and paper based prepares me for test.

S10/061. Web-based homework graded itself, so I HAD to do it all of the time or lose points. I did more web-based homework than paper-based because paper-based wasn't graded. HOWEVER, I think paper-based would have been more effective, had I done it more frequently. This is because the web-based homework was very easy to get through without trying very hard, i.e. it gave a very specific tutorial that guided me to the answer without a lot of effort.

S10/062. You are physically doing the work. It is written down for you to remember and ask questions. It is difficult to ask your professor questions about online homework. It is also frustrating when you have found the correct answer but can't figure out the way you're supposed to type it in to get the points, and when you have to work 3-6 parts on a problem to get 1-2 points, and if you can't answer all 6 parts, then you don't get any of the points.

S10/063. has more explanation.

S10/064. b/c i'm not good at keeping up with on-line homework and when it doesn't work right i get the bad end of the line. i'm more traditional anyways and like to hold what i'm doing and write out my thoughts.

S10/065. The online homework has its benefits because it can show you how to do a problem if you cannot figure it out. But even then it has its limits. Paper-based homework is also good because you can go back and look at your work with no computer.

S10/066. I think we can look it again and again. Online homeworks you have to be near the computer to reviewe it

S10/067. retain information better when i write it down

S10/068. By far I believe paper based homework to be more beneficial. I KNOW that it is for me. Online homework for one takes way to long to access if your lucky enough to be around a computer. Paper based homework can be carried around and studied much more efficiently. Also I'm a firm believer in kinetic memory so writing the problems out on paper is more beneficial than typing (unless the format of the test is also typing on a comp). The absolute best style of homework for actually learning the material are worksheets with problems on the front, and step by step how to work them on the back. That way students can work through problems and see exactly what they need to work on and how to fix it.

S10/069. If a concept is hard to understand, the online program should be able to walk you through the steps; nevertheless, I like paper homework because that's what Im used to doing.

S10/070. If you do not understand the homework, then online will try to give you hints and work you through the process.

S10/071. I dont know... I guess I'm old school. I am in that generation where technology was just starting to come around when i entered college for the first time....Especially web based homework. For some reason, I felt that the worksheets and practice problems [Instructor's name] passed out and worked on with us was much more effective for my style of learning.... [Instructor's name] is a great professor and the web based stuff comes off as a bit stale sometimes so naturally I prefer the person over the computer.....dont get me wrong, technology has its place in education but.....

S10/072. I think the web-based homework helped me to understand material and be able to reinforce it, but alot of the time in [Instructor's name] class, online homework was wrong and I got a bad score that hurt my grade. also, it was hard to figure out how the program wanted you to enter your answer. at least three times I spent over an hour on one problem trying to type the answer I KNEW WAS RIGHT in the way the program would accept it.

S10/073. Because its easier to keep up with and I make notes from the online homework.

S10/074. I feel this is more effective because we are not pressured to get the answers right, yet we can see what we miss without losing credit.

S10/075. It is a lot easier and faster to check your answers on a computer than in a book, so you can get much more done

S10/076. They offer online tutorials to questions that one may consider to be difficult.

S10/077. If created by the professor, we then have an additional resource from which to familiarize ourselves with her/his typical approach in presenting problems. The work then being tangible, I am there much more likely to bring up questions with my professor after class, or during office hours than I would be were they questions from an online assignment. I find it easier to identify my challenges when working through similar problems on a worksheet/ assigned book problems. Additionally, material was covered on the online assignments which was completely skipped in class, which some of the students (including myself) found frustrating. These assignments were, however, much more helpful than those required during the spring 2009 semester under [Instructor's name]. When a problem was answered incorrectly, the further explanations/exercises were quite helpful.

S10/078. The homework online has tutorials that come with it.

S10/079. The explanations are detailed and precise.

S10/080. because it guides you through the problem

S10/081. It is very expensive to do web-based homework. With college students, we do not have a lot of money so it was very expensive to me. So the most cost effective is paper based. In addition, it is hard sometimes to get on the internet to do the homework. Another concern, when the computer systems are down, you can not do the homework. I would like to stay with traditonal paper-based homework.

S10/082. It allows the student to find out how to work problems on their own.

S10/083. Easy to forget about- I spent more time trying to figure out the correct method to type stuff in too much hassel and problems to outweigh the good. I would do better with traditional homework.

S10/084. It gives you helpful hints if you're having trouble understanding the concepts or even doing the math. The thing that is not so helpful with it being online is that sometimes it's hard to enter in the chemical formulas and it's difficult to understand what you're doing wrong.

S10/085. Online homework is sometimes flawed. Paper-based homework you can receive half-credit and it's not just right or wrong like online homework.

S10/086. More likely to remember to do it and more willingly to do it

S10/087. The online homework says when something is wrong and often explains why or gives helpful hints.

S10/088. It's better for me to do problems on paper than the computer.

S10/089. OWL pros/cons: 1. The answers had to be input in a certain manner, which was rather annoying and frustrating. A
missing hyphen = an incorrect response.
2. Questions with multiple parts required that I answer all the parts in order to receive credit
(drawback 1 played part sometimes, which added to the frustration).
3. Internet access is not always available--work/network is down/...
4. The hints were helpful sometime.
5. Costly! And with all the quirks, it is not worth the price.
6. Not always related to lecture.
Paper- 1. It's cheap!
2. definitely related to what we had gone over/going over in lecture. It's a hit or miss with OWL.
3. Able to do some of the question during lunch breaks at work.

I personally prefer paper-based homework (my professor may not :-)).

S10/090. The online homework is no where near refined enough for practical use. Answers sometimes do not count as correct, even though they are in fact the correct answer. Also a majority of the time you still have to get paper and write out many things for the homework. This makes the entire homework process more time consuming and less enjoyable. The online homework is

easier for the teacher and takes less class time but I think incorporating the homework into the class would help everyone do better.

S10/091. It just seems to stick better for me than web-based homework

S10/092. It gives me tutorials and examples. Some are very detailed and step-by-step, which is very helpful.

S10/093. computer can be wrong

S10/094. everyone is on computers these days and I think its easierr and more efficient this way

S10/095. They are both equally effective. Sometimes online homework is more convenient, however the system errors are frustrating. I do not prefer one over the other.

S10/096. because it is something you can review anytime and plus work your problems out.. web based is usually helpful, but without the internet you will not be able to do it..but paper you can do it anytime.

S10/097. Online you can guess just to get through it

S10/098. I believe homework should be based on the effort you make and i prefer go have the actual material that the professor is covering . The online homework is way to complicated for Chemistry with all the signs you must put and the formatting is to complicated a lit of the time thats what takes me so long is just being sure i formatted it correctly its extremely irritating .

S10/099. I LIKE THE LIVE TUTORIAL OPTION

S10/100. The hints given online are better than no hints at all, as on traditional homework.

S10/101. I am a grown 28 yr old married man of 9 years and the huge amount of homework is bullshit. it has made it very difficult for me to do even half of it. 2 jobs, 2 kids, and other life related business along with other classes im taking that are more important but way easier. IF THE ONLNE HOMEWORK ALLOWED US STEP BY STEP HELP WHEN NEEDED THAT WOULD BE MORE EFFECTIVE LIKE IT WAS LAST SEMESTER IN [Instructor's name] CHEM 1. IF I CANT FIGURE A PROBLEM OUT ON MY OWN, HOW THE HELL AM I SUPPOSE TO DO IT WITH NO

KIND OF HELP OR STEP BY STEP INSTRUCTION??? I HAVE BEEN VERY DISSAPOINTED WITH THE SETUP OF [Instructor's name]'S CHEM 2 CLASS ALONG WITH OTHER PEOPLE..... PEOPLE LIKE MYSELF HAVE A LIFE AND OTHER CLASSES TO WORRY ABOUT RATHER THAN HAVING EXACTLY 30 HOMEWORK ASSIGNMENTS DUE EVERY 2 WEEKS!!!!!!!!!!!! GET REAL!!!!!!!!!!!!

S10/102. because you can see where you went wrong on the problem, and also b/c paper-based homework is easier to conceptualize the problem and b/c paper-based homework is generally closer to the problems worked in class. OWL does nothing but confuse me.

S10/103. because your actualy writing things down, and they usually stick more in your mind.

S10/104. It keeps the consumption of materials (paper, ink, etc) down, and the students like the interactivity. However, there is something to be said about the type of questions are asked and how the "tutorials" help. I like the fact that there are tutorial questions but, I just go through them and don't really retain the information, or "connect the dots". Online Homework is good in theory, but in all honesty, not beneficial.

S10/105. Because if something is wrong, it is easier to get help from the professor and he/she can correct you. While when it is web-based, you only have the tutorial to help which doesn't always make theproblem clear.

S10/106. It requires that I actually look up, learn, and apply the concepts.

S10/107. I dont use the online homework to learn, I just go through it and use it to raise my grade.

S10/108. The online homework gives you a step-by-step guidance if you don't know what to do. Paper-based homework, if you get stuck, there is nobody there to help you out. You would have to wait until next class period to find your professor or find outside sources to help you with your homework and that sometimes costs money. I think the Web-based homework is more effective for me because it actually explains concepts to you and helps you solve problems.

S10/109. you can work it out and learn from it.

S10/110. With Web-based, it is graded using specific formats which can cause a student to get the entire problem wrong, simply because the computer wasn't able to

"read" it. Furthermore, OWL requires you to answer 3-4 problems to get a single credit. In that case, if you do 2 out 0f 3 correctly, you dont receive credit and must redo al lthree problems which can take alot more time and result in no received points.

S10/111. It is easier to get help and/or tutorials for problems. It is explained more throughly online than in our book.

S10/112. You get a chance to write out the homework

S10/113. because you are working the problems on your own and the way most tests are the old fashioned way.

S10/114. The tests are paper-based. If the homework is also, it helps for a better visual.

S10/115. The online homework is frustrating when the computer or internet is not working correctly. It is not done conveniently between classes during the day, cause you must have a computer to do it. If a wrong button is pressed the whole question is wrong, where as if written a button would not have to be pressed.

S10/116. It would be easier for a grade and people would be more likely to do it, since over half of students time/work is done via computer

S10/117. Online homwork gives better examples and is oftentimes more convenient because it can be done from any where a computer is located.

S10/118. I feel it is more involved with what is taught in class, and it is more related to what is on the test.

S10/119. On the Online homework, we just guess until it tells us how to do it. We aren't learning. Most of the time, even if our answer is right, it won't accept the answer preventing us from getting credit on that question because it keeps us from going on the next section of that question.

S10/120. With many of the online homework websites, you can look at example problems or the answers after so many attempts, which I believe is very beneficial if you do not have a very good instructor. All people learn differently, some may benefit more from hearing a professor lecture, but others may benefit more from doing example problems and online homework. For example, I personally learned better in my math courses from online homework compared to going to class learning from the teacher I had. I believe web-based homework would be very helpful.

S10/121. I think you learn more when you write something down bacause it puts it in your head.

S10/122. Depends on the person. For me, I like traditional paper because it is easier for me to see all of my steps when working the problem. Online can be useful in that when the user gets it wrong, it helps them figure out the problem through steps. However, some students may take advantage of this help system and simply use it as a means of eliminating answers. Also, I personally ran into quite a few errors in the system itself where the answer would be counted as wrong simply because of a formatting error or because there was something wrong with the question. This is extremely frustrating and there is nothing the student can do to fix it.

S10/123. because it would be easier to study from because most of us can't read our own hand writting

S10/124. Some people may not have quick access to online homework. Also, computer homework will have a glitch and not accept a correct answer even if you have worked and checked it numerous times!!

S10/125. Using paper to do homework is easier to handle. You can spot your mistakes faster than you can online. When doing homework on paper, you can have breaks. When you do it online, you may be timed and have to do other problems you didn't miss to get a higher score.

S10/126. If you are assigned online homework you know if you are getting the right answer or not.

S10/127. Because you are able to recognize your mistakes and get help on them while you are doing the homework instead of waiting two days to get help from a professor or anyone else.

S10/128. Because if I transcribe something onto paper not to it's specifications the piece of paper doesn't count my work wrong causing tedious hours of grief. You basically have to learn a new language in order to use the online homework. I think it hurt me more than helped me. It definitely took away from my traditional studying time which is much more beneficial.

S10/129. Doing problems directly relating to what is being taught in class and on how the teacher teaches the material is much more understandable then online questions.

S10/130. Because with Web-based homework such as OWL, it helps walk you through

steps to get a better understanding and how to complete it. With traditional paper-based homework, the answer might be in the back of the book with some problems, but doesn't explain how to get that answer.

S10/131. Web questions often give tutorials, and make it just plugging in numbers, not learning.

S10/132. physically writting the problems out, when it comes test time you will be better served by manually doing the writing and problem solving than clicking the mouse for online hmwk

S10/133. (There should be an undecided button for #22 above..)
I selected traditional paper-based hw because the web-based system was a little bit tedious at times.. I remember a question where it was just impossible to enter the right answer, due to '_' and '^' characters.. There were a few questions that were a bit too extreme for the course material that we were covering.. It was extremely helpful, however, in the way that it offered you assistance automatically when you got a question wrong; and in that way, I do really like it better.. There's just a few kinks that need to be worked out.. Especially if students have to pay to use it if they bought a used book.. I don't agree with that..

S10/134. I have to do math homework online, and i find that the deadlines are hard to complete sometims because i live at home and work two jobs so sometimes my internet goes down, or my computer freezes. I also feel as if i dont learn anything during the online homework.

S10/135. Writing out the problems helps me to remember the material. I tend to do this with OWL work still. With OWL, however, if you miss a problem the system corrects you making it easy to coast through the homework without learning much. OWL seems flawed in many aspects and I have had trouble with it since the first assignment.

S10/136. You can find out quicker whether or not you are doing something wrong, plus I like the "thinkwell videos" for when I still quite haven't caught onto something

S10/137. Best because you receive immediate help and feedback.

S10/138. there is faster access to related information that is necessary to fully understand the concepts. the only issue i had with owl is that at times, the answer entry format is cumbersome and a time-waster.

S10/139.	Because it's something that's right in front of me and I can carry with me and look at for reference if I ever needed to review something.

Fall 2010

F10/001.	I don't know about chemistry online homework, but sometimes with math online homework, if the question is answered in the wrong format, it does not accept, so it becomes more frustrating than productive.
F10/002.	It is more convienient
F10/003.	I learn better by writing and reading what i wrote. When I do online homework, I usually end up having to write it all down to understand it anyways.
F10/004.	The problems are there in front instead of on screen
F10/005.	sometimes the tutorial used with online homework is more helpful than the examples given in a textbook.
F10/006.	Web-based, because if its like course compass for some math classes, it will tell you if you did the problem wrong, and give specific examples and walk-throughs on how to solve similiar problems.
F10/007.	writing helps to make it stick
F10/008.	Online homework will show a teacher that you answered each question right or wrong. They will not know how you came up with those answers
F10/009.	It tells you the correct answer then
F10/010.	You can receive more adequate feedback from a professor.
F10/011.	its easier to correct your mistakes and learn from them
F10/012.	It didn't apply to the class and material we were going over. Also, the due dates of the assignments were NEVER posted except on the OWL website. So, you had to check the website everydat to make sure you didn't miss an assignment. You could tell teachers didn't care about it, which made students not care about it. But it is a grade for us, and that didn't benifit us.

F10/013.	i did not try web based homework
F10/014.	Writing it down helps it stay with me.
F10/015.	because i want forget to do it if i have to turn it in
F10/016.	I am always around a computer and work better on them
F10/017.	It breaks everything down into step by step instructions when you get an answer incorrect.
F10/018.	Feedback was available when I had problems with a procedure that helped me learn how to work the problems better.
F10/019.	Because online homework shows u how t work the problems out.
F10/020.	Online homework is a terrible idea. Especially for Chemistry.
F10/021.	The homework done in a book can be checked by the back of the book, and it has the methods to help get the correct answer. The online homework doesn't have a pop-up periodic table of elements, formulas, or good explanation for why and how things should be worked out. Because of the missing data on the online homework, the text book is required to do the problems. Although this wouldn't thought to be a problem, when using a computer at home or at school, the deskspace is a limited resource which is normaly taken up by a mouse and keyboard, this makes it hard to keep your place in the book, use the periodic table, or type in your answer. Because of all this, more frustration is added to an already difficult subject and once the homework is complete the only thing that is remembered is how frustrated you are about doing it instead of how to work the problems.
F10/022.	I don't know how other people are but at least i know i really don't have much time to sit down with a paper and pencil and try to do my HW. Plus, people these days uses computer and internet for everything. I believe people are more motivated to do it if it is online homeworks. I don't know if this matters but it kills less trees
F10/023.	It includes helpful hints, almost like a virtual teacher. It also breaks down the problem to smaller steps for further understanding.
F10/024.	actually writing the information seems to give me better recall - I'm not simply reading it this way, I'm having to think more about it as I write it down

F10/025.	It overs help and feedback right away.
F10/026.	Because if you are unfamiliar with a problem the feedback walks you through it.
F10/027.	But the must include more step by step tutorials for students that dont understand how to do the problem. It is more helpful because it has all of the answer and that helps students understand what they are doing wrong. If you do paper based homework you dont know the answers until you teachers has given them back and you have moved on to something else even more difficult.
F10/028.	because you can see what your doing wrong. The teacher may not go over the traditional paper-based homework.
F10/029.	Because it shows you how to do the problem if you miss it and goes into detail on how to do each step.
F10/030.	because it gives you hints more feedback helps you understand the material more
F10/031.	I feel like traditional paper-based homework is easier to understand. Writing it down and being able to flip back to an example problem in the book is better for me.
F10/032.	Although the online based homework is helpful in guiding the student to the right answer in many times, the online based homework is also currently formatted to not allow any key stroke mistakes whatsoever. If the entered answer is entered incorrectly due to confusion of desired format or even a general miscue, the entire problem is often marked absolutely incorrect and is made very difficult to fix there after. Paper based therefore is simpler and forces the student to seek help if not able to do it on their own.
F10/033.	I think both are comparable because when I am doing online based homework I use my book to do the problems. Although, I am able to search the internet for any questions I have when I do not have my book available and I would be around a computer more often than my book.
F10/034.	Most students are on their laptops or computers, having online homework would be easier because the technology is already there and just ready to open up a window and start.

F10/035.	If you don't know how to do a problem, the online homework provides a tutorial.
F10/036.	writing problems out and writing all the steps out helps me remember things alot better. I also like having everything on one piece of paper to refer back to if i need to
F10/037.	The overall process of web-based homework is much simpler, and neater, when compared to paper-based homework. It feels more interactive than doing problems out of the book, especially when the homework systems have integrated resources in different multimedia formats. Online homework systems tend to provide immediate feedback, which is particularly helpful when you've gotten the answer wrong. It allows you to immediately address whatever problem you are having with a particular concept.
F10/038.	it has a tutorial
F10/039.	Because with the online homework, you are able to find out immediately whether you are right or wrong and it also gives you hints when you are stuck. Without some of these hints, I would have been lost on some problems.
F10/040.	The MasteringChemistry program was a pain to find time to do, but it does help because it explains practical application of what we were learning in class and gave step by step of how to figure the problem.
F10/041.	because you remember things more when you write them down
F10/042.	Less paperwork. The online homework can also give you feedback--hints, what you did wrong, etc.
F10/043.	Writing down the problems and work help me more
F10/044.	not sure
F10/045.	I have to do online homework for Pre-calculus class and not only do I have to type in my answers but I also have to get out paper and work them out, which is what I have to do with paper based homework anyway. These online assignments allow for more grades in the gradebook thus, they not only help me learn but also raise my grade. There is also the option to "watch it" in which a similar problem to the one I need to solve is worked out for me.

F10/046.	I think they are both good. What I liked about the online homework was that I knew if I got the answer right or not and could continue trying it if it was wrong. Also, I liked how it gave hints as to how to do the problem. That helped a lot.
F10/047.	You actually have a log of your work. It is easier to see your mistakes and you don't get it wrong if you actually mistyped something. Also it is easier for some one to help you this way!
F10/048.	It is more conveinient for me as a student to do online homework because i'm online half the time anyway.
F10/049.	I feel that writing the homework on paper makes you understand the material more. I did not enjoy the online homework. I felt like the online homework was harder to understand and was harder to complete because of the specific ways it had to be entered.
F10/050.	better rmember if you write it
F10/051.	it allows students/teachers to keep track of the assignment better. And it is often more helpful than paper-based homework.
F10/052.	Because your physically doing it, it stays more in your head and is easier to remember.
F10/053.	Can be completed on your own time. Feedback is received almost immediately. Concept tutorials are very helpful.
F10/054.	With online homework programs, a student can get more personalized feedback, hints, and other help that would not be possible with traditional paper homework. With that being said, the online homework can mistake a correct answer for an incorrect one sometimes, which can be really frustrating.
F10/055.	It allows feedback and helpful hints in order to understand where you went wrong and how to get back on track for maximum understanding.
F10/056.	Our generation is used to using computers for different tasks. Also, its all online so you can do it anywhere. Oppose to traditional homework you would have to carry it around all the time. There are computers all over campus, so it is very easy to get in a couple of problems inbetween class

	and not have to carry so many books.
F10/057.	With online homework, there is a large span for patents. Though your doing the problem right, the tiniest bit of error makes the problem wrong, so you have to go back and do a 20min problem all over again. It is too time consuming, and due to the fact this is not my only class, I will often become concerned about just the procedure of where to plug in things in the problem and throw concept out the window. It just doesn't work for me.
F10/058.	It is easier for the student to understand and work at their own pace rather than having to write down the problems and have to erase. Online homework works well because you can work on it at your own pace and be sure that it is completed the day it is due without showing turn paper work. Also, the student gets a grade as soon as they turn it in on online homework.
F10/059.	The student has to actually take a pencil and paper and plot out problems (mathematics, visuals, drawing, etc.) This allows the student to actively learn the material and also allows them to better apply the work process.
F10/060.	If you don't enter the online answers in the correct way (subscripts, notations) you think your answer is wrong and you end up confusing yourself.
F10/061.	because when i messed up it sent me through a tutuorial which showed me the steps
F10/062.	I just like having regular homework because doing the problems help me go through the same types of problems that my teacher will ask on the test. They are different than the ones online most of the time. However, I do like the OWL homework we've done because if you get it wrong you can correct it, unlike most homework that gets turned into a teacher.
F10/063.	It's sort of like having an extra helper. For example, sometimes when I missed a problem it would have me go step-by-step to find the answer so it made it a lot easier to comprehend.
F10/064.	only when not som much is given, it helps because you have the chance of correcting yourself, but when you have too much it makes it overwhelming

F10/065.	It is SO helpful to use the tutorial when you are confused as a learning tool rather than just being frustrated with book work.
F10/066.	I feel like I learn more when my homework in in paper form instead of online becasue I pay more attention and try harder with paper homework.
F10/067.	Because online tells you instantly why you missed certain problems or how to solve them
F10/068.	Writing things down helps me sort everything out so I understand what i'm doing. Even when I do the online homework I work out the problems on paper.
F10/069.	It just teaches me more than online.
F10/070.	because when you get a problem wrong on the online homework they give you tutorial questions that shows you how to do it step by step
F10/071.	Although I believe both types of homework are effect, the online homework was more beneficial to me. The student is able to recieve a quick response as to whether or not the answer was correct and if her/she ultimately struggled with the problem they are able to work it out step by step with the program.
F10/072.	it provides helpful feedback
F10/073.	While I think an online based program provides instant feedback that is necessary, I'm not convinced that the OWL program does that efficiently.
F10/074.	no paper as well as immediate assessment
F10/075.	I like having the book in front of me so I can reference material more easily, but since [Instructor's name] refuses to offer help outside of class and the tutors in the chemistry tutoring center need to take remedial algebra and remedial chemistry because a 6th grader would be a better tutor, I found the online material more useful because it knows the material and gave me feedback as to why I missed a question. Also, anything is better than just sitting through a teacher reading a powerpoint
F10/076.	The online homework, at least on OWL, doesn't show you the answer

	90% of the time there is also far too much in each assigned section. Bookwork tends to at a minimum show you the answer so you can work toward it. If they made OWL more like WebAssign then I think it would really be a great resource.
F10/077.	Because it is easier to correct the problem if you did it wrong and not get counted off for a try.
F10/078.	Because most people have computer now and if they do not then they can go to the library or a near by computer to do it. also with most online homework, there is a place where you can also print it out if you have to work it on paper..which is a good thing.
F10/079.	I am not fond of online homework, but at least when you do it online you can get feedback right away. The feedback might not always be helpful, but it's better then waiting a few days on the professor to give you back your work. Also, it is nice knowing the grade you got on it right away.
F10/080.	Its really mixed. The web based homework is nice because you find out immediately if you are correct or not and if you are having problems it gives you hints to guide you along. The only problem with that is sometimes you dont really have to understand the material to still complete the homework perfectly.
F10/081.	It saves paper, and it can help you know if you got it wrong so you can do it until you get it correct
F10/082.	all i know
F10/083.	It involves the student in the full process of the problem, not just pointing and clicking an answer. Personally, I learn better by doing the entire process myself.
F10/084.	Because physically writing the equations and performing the calculations necessary for the fundamentals of Chemistry are better retained than typing them. Also, having a professor point out what steps I've done wrong with written homework is much more effective than a computer simply telling me I got a problem wrong, and not why. I've also found online homework in other classes to take a considerable amount of time compared to written, because I have to write the problem on paper to solve it and then translate it to the correct format the online homework requires. Quizzes however are extremely simple and more efficient than

	written, but only if multiple choice.
F10/085.	"Slow and steady wins the race."
F10/086.	Because people are more likely to do their homework when it's easy to answer and submit, such as the online homework.
F10/087.	WHen doing online homework you tend to forget to do it and also you get to see what you are doing when you write it on paper.
F10/088.	I have always done homework on paper.
F10/089.	It just keeps all the notes and work you've done in an organized manner and keeps you from having so much papers that you don't even know what to study for. Having online work lets you keep track of the section by section material and presents online help and practice problems and is much easier to remember and accomplish than traditional paper work. It also saves a lot of time on the students part taking away confusion and the teachers time from grading every little detail when the computer can automatically check that for you so it gives every student more time needed to study for the actual tests and exams rather than taking hours to do just a few problems.
F10/090.	By doing traditional homework, the student has the ability to briefly do exercises to refresh his memory. The online homework allows no shortcuts or shorthand notation making it take much more time to complete. I personally do all of the assigned online homework and the end of chapter reviews in the actual textbook. I find the end of chapter reviews prepare me better for exams based on the number of similar questions found on the exam. Understandably this may be a feature of the professor and not the design of the course. I'm sure that if the online homework was more representative of the exam my professor chooses I would consider it more useful. At this point the OWL learning system is more of a chore than a learning aid.
F10/091.	Its convenient for everyone.
F10/092.	I'm bette when I'm actually writing things down. It stays in your mind better that way. Paper-based homework would help me alot more than internet
F10/093.	Often times when doing online homework answers to problems are

	correct, however the format is incorrect and the computer will count correct answers wrong. This results in homework taking way longer than it should and also being much more frustrating. Paper homework can be graded by the teacher and provide more accurate and personal responses to help the individual needs of each student. There are online classes that people can sign up for if they wish to obtain an education from the computer. Otherwise education should not be on the computer. Students pay for Professors to teach them, not computers. Paper-based homework can also be completed anytime and anywhere. Online homework requires that the student have access to a computer. Computers also crash and websites frequently are inaccessible. Computer screens can also be harmful to an individual's eyesight and CNS function.
F10/094.	online homework helps shows you when you are wrong and how to solve it so you know you are doing it right
F10/095.	Usually, web-based homework is easier to gain access. Most of the time, online homework is graded immediately and the students are able to know their scores.
F10/096.	Paper allows you to see everything at once and have many pages laid out in front of you. Online is hard to read because it is confined to the webpage, and looking back and forth between pages can be confusing if you lose your place.
F10/097.	Instant feedback. Would be better if the homework could show you the solutions as well so you would know where you might have went wrong.
F10/098.	I can't speak for everybody, but if I turn on a computer, I am immediately tempted to log onto facebook. Also, online homework is easy to get around, as in you don't necessarily have to know the material. Now a days, answers can be found on google. The only problem with the traditional homework is that it is never picked up anymore, so you don't always know if you answered the problems correctly.
F10/099.	It makes the student work harder. The downside is no instant feedback. However, the feedback is often confusing and unhelpful. Supposedly, OWL is an integrated system that allows the student to ask questions about specific problems and get feedback online from their teacher. If this avenue was better developed/promoted it would have my vote.

F10/100. The online homework penalizes you for spelling/input errors, and marks the entire problem as "Incorrect" if you miss just one small part of the problem.

F10/101. I feel as though writing something down on paper and going throuhg the all of the processes is more effective than simply clicking on an answer

F10/102. It gives you the correct answer and feedback on how to get it.

F10/103. The online homework is usually formatted differently than the lecture class test, so it is usually not helpful at all and it is extremely time consuming.

F10/104. I feel that having to write down the problems with easy reference to the text book is more effective. Also, I do not like having to do all of my homework sitting in front of a computer. This is difficult when a computer is not always easily accessible. Also, it allows you to complete the assignment on your free time, rather than having it due by midnight.

F10/105. because it doesn't give all the options the web based does

F10/106. Better understanding of steps and equations as well as partial credit for correct set-up. Online homework can be tricky and be counted wrong if you have the correct answer, but incorrect formatting or typing error.

F10/107. Although it is much harder, it is more helpful because it instantly give us feedback on how to correct it and try again. Also, it saves time.

F10/108. It depends on if there is online help with the online homework. If there is then it would be more helpful. However; any homework that is graded by the professor is better since it would be positive feedback on what the student is doing and how they should study and what they should study more on.

F10/109. The online homework does take forever to do becuase of wait time on each question and the preciseness that it requires to get a question correct. However, I do like that it tells you if you got the question right or not right after you do it.

F10/110. Having your homework on paper requires effort to actually think while you are writing. Web-based homework is always a chance on if the Internet is available or you can even get to a computer. Therefore more time and effort is needed to simply get to the homework when it should

be spent doing the work.

F10/111. Online Homework does not affect the way I learn as paper homework does. On many occasions, I have punched in random numbers simply because I could not come to an answer. My random guessing gets me the grade. With paper Homework, you submit it and it is evaluated, you get one chance and you learn from that chance.

F10/112. i feel like for me personally, i do not learn on a computer, writing the information helps me to learn it.

F10/113. Only because it is easier to keep up with, and if you do get stuck it gives you helpful hints on how to work out the problem.

F10/114. I tend to forget that I have online homework and by the time I do remember, it's too late to complete it for credit.

F10/115. I don't like spending that time in front of a computer. Doing homeowrk out of the textbook, I am more likely to refer to areas that I don't understand rather than blindly stumbling through it on the computer

F10/116. There was a turtorial that walked you through the problem to make sure you understood it instead of just answering it. Not to mention you could check your answers, you can't do that with traditional homework unless there is an answer key

F10/117. It's more practice than just putting numbers in a box and checking them

F10/118. home work that is similar to test material, current chemistry lacks

F10/119. because it is graded faster and you are able to see what parts you are doing wrong and fix it.

F10/120. ease of use. I can almost always find a computer to do homework, but sometimes I may leave my book at somewhere and wouldn't always be able to do book based homework

F10/121. It's easier to write down my thoughts and essentially follow that trail. Sometimes I might lose focus, or I might have to put it down to do something else real quick, and it's easier if I can come back and follow my train of thought by reading what's already been written down. The online doesn't give me that option of taking notes, or coming back to it

later.

F10/122. For me personally, writing problems makes me think about them more. If I physically write and work the problem I will be more likely to remember it. Also, online homework tends to be harder for me since the degree of difficulty doing mathematical problems on a computer is much more frustrating.