The Effectiveness of Online Homework Tutorials as Compared to Pen and Paper Tutorials

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THE EFFECTIVENESS OF ONLINE HOMEWORK TUTORIALS AS COMPARED TO PEN AND PAPER TUTORIALS

A Thesis

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Natural Sciences

in

The Interdepartmental Program in Natural Sciences

by

Molly Shuman
B.S., Wittenberg University, 2010
August 2015
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The purpose of this study was to determine if students learn more from completing web based homework (WBHW) compared to completing homework by traditional means with pen and paper. Determining the efficacy of WBHW is important because many schools are being pressured to implement technology in the classroom. To determine the effectiveness of WBHW, student normalized learning gains were calculated from pre and post-test scores for 62 students. Learning gains were then compared when students completed WBHW, traditional homework, or did not complete homework at all, over four units in a high school chemistry class.

No difference in learning gains were observed between the students completing traditional homework and those completing electronic homework. However, those students that completed either type of homework had significantly higher learning gains than those that did not complete their homework. Students were more likely to complete their homework when assigned on paper (86.7% of students) than on the computer (64.4% of students). Students also self-reported a preference for paper homework to WBHW. For example, 66% of students reported good or great learning gains as a result of traditional homework, compared to only 10% of students reporting the same for WBHW. The results of this study, demonstrate the importance of educators assigning meaningful homework in a method that students are likely to complete. High school chemistry students showed a preference toward traditional methods but, either method of homework completion was related to positive learning gains for students.
INTRODUCTION

Rationale for Study

Throughout the history of education in the United States, the amount of homework assigned to students and its effectiveness has been a topic of disagreement amongst educators, administrators, parents, and researchers. While it is commonly accepted and supported by research that completing homework will positively affect student learning (Beesley & Apthorp, 2010; Demerci, 2010; Maltese et al., 2012), it is not clear whether the type or amount of homework is most beneficial to students. In an education system where student learning gains are tracked and success on standardized tests impacts teacher, school and district evaluations, homework will continue to be a major part of our student’s education.

This increased focus on student success and high stakes testing has led school districts to change the way they teach students. While content requirements continue to be refined, policy makers are also focused on preparing students to be 21st century citizens. To meet this demand, along with increasing class sizes and demands on teacher time, many districts and schools are encouraging the use of technology with all students. By integrating the use of technology into classrooms, students are given an opportunity to become digital citizens, which provides teachers and districts a path towards improved evaluations. One way for teachers to increase the use of technology is to implement web-based homework systems, or online homework. As of 2003 it was estimated that over 100,000 students use online homework systems in the U.S. (Bonham, et al., 2003). While there are many benefits to using online homework, it is not always an option for teachers, and education researchers have not been able to definitively say that online homework results in greater learning gains for students (Allain & Williams, 2006; Bonham et al., 2001; Cheng et
al., 2004; Demerci, 2010; Kodippili & Senaratne, 2008). The aim of this study, was to determine if the implementation of the web-based learning program *Success Net Plus* developed by Prentice Hall to accompany *Pearson Chemistry* (Wilbraham et al., 2012) will result in greater learning gains for students enrolled in a high school Chemistry I course as opposed to students completing identical activities on paper. Due to the ability for students to view animations and receive immediate feedback, it was anticipated that students completing the interactive web-based homework would have significantly greater learning gains than students that completed the homework on paper.

**Literature Review**

Many studies have been conducted pertaining to the effectiveness of different types of homework (Eren & Henderson, 2011; Maltese et al., 2012; Trautwein, 2007). Researchers have attempted to show connections between student success and the amount of homework, type of homework and the populations performing the homework. Some important findings in the research include: the importance of homework as practice, the need for meaningful feedback, and the positive effects of online homework on student learning gains.

Many teachers use homework as a way to engage students in practice of skills learned in class, such as math homework or problem sets in chemistry or physics. In such cases, when practice is assigned as homework, teachers have less control over how and if the students will complete the homework (Beesley & Apthorp, 2010). In other cases, such as the instance of a flipped classroom, homework is meant to provide the students with knowledge prior to in-class activities. In either case, evidence suggests that completion of homework corresponds to greater learning gains compared to situations where homework is not assigned, or not completed (Bonham et al., 2003; Demerci, 2010; Trautwein & Ludtke, 2009). It makes sense that those students who complete homework would
perform better on tests. For example, they have spent more time engaged with classroom material, and in the case of practice-type assignments, it is expected that those practicing any skill more often will be more successful at performing that skill. This is useful information, however it should be noted that many studies have also supported that assigning the same number of assignments with more questions does not improve learning (Beesley & Apthorp, 2010). Rather, a study by Trautwein (2007) suggests that giving more frequent homework assignments may increase the average learning gain of an entire class, but effects on individual student learning gains within the class were not significant. Thus, the type and amount of homework given to students may be context-specific and more studies are needed to better understand the significance of homework to student learning and success (Trautwein, 2007).

Given that homework often improves student test scores, it is interesting that additional time spent on the same homework assignment does not show a correlation to higher test scores in history, English or science in a sample of 8th grade students (Eren & Henderson, 2011). Yet increased homework time does show positive correlations with test scores for math (Eren & Henderson, 2011). One possible explanation for this is that math homework tends to be practice-type assignments; therefore, those students spending more time on the homework are receiving more practice. Homework in other subjects may serve to introduce or reinforce knowledge. In this scenario it may be that the students spending more time are doing so because they are lower performing students, or because they are spending more time off task (Eren & Henderson, 2011). Another study by Maltese et al. (2010) suggests that additional homework time in both science and math corresponds positively to performance on standardized tests, but shows no correlation to classroom grades. This
supports the idea that more practice benefits students’ mastery of skills being that standardized tests are often skill-based and not content-based.

Regardless of the type of homework, and the amount of time spent on the homework, many studies indicate that it is essential that students receive feedback on the homework (Allain & Williams, 2006; Bonham et al., 2003; Cheng et al., 2004; Richards-Babb et al., 2001). Feedback not only allows both the teacher and the student to identify problem spots, but it also makes the assignment more meaningful for the student. While feedback is helpful, using class time to check answers does not increase test scores (Beesley & Apthorp, 2010). Possible explanations for this include that class time used to check answers could be used in more meaningful ways, and also because it does not provide students with specific targeted feedback nor does it force all students to reflect on their errors. Ideally students would receive feedback that is immediate and thorough, however with increasing class sizes this intensity of feedback is often not possible for teachers to maintain. Web-based homework (WBHW) offers a trade-off between the two above mentioned feedback styles. While WBHW provides immediate feedback, it is often not specific, conversely traditional paper-based homework may allow the teacher to provide thorough and specific feedback, but it is often delayed (Bonham et al., 2003).

Many teachers find the use of WBHW appealing because it decreases the time spent grading. Likewise, students generally have positive feelings about online homework (Bonham et al., 2003; Demerci, 2007; Richards-Babbet al., 2001). The following table (Table 1) summarizes the findings from the Richards-Babb et al. (2011) study, which illustrates the overall positive attitude towards WBHW in chemistry that was perceived by the students.
Table 1. Student views on web-based homework in an undergraduate general chemistry class (Richards-Babb et al., 2001).

<table>
<thead>
<tr>
<th>Viewed WBHW as</th>
<th>Percent reporting positively</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favorable</td>
<td>80.2</td>
</tr>
<tr>
<td>Worth the effort</td>
<td>83.5</td>
</tr>
<tr>
<td>Relevant</td>
<td>90.5</td>
</tr>
<tr>
<td>Challenging</td>
<td>83.4</td>
</tr>
<tr>
<td>Chemically thought provoking</td>
<td>79.0</td>
</tr>
</tbody>
</table>

Some reasons why students generally like online homework are that it is interactive, possibly animating difficult to conceptualize concepts, and it provides immediate feedback. From a perception point of view, therefore, there is evidence that both teachers and students find WBHW beneficial.

In addition to the positive views of WBHW, studies show that WBHW increases the amount of time spent on homework and the scores that students receive (Allain & Williams, 2006; Demerci, 2010; Richards-Babb et al., 2001; Smolira, 2008). It is logical to attribute both the higher scores and additional time spent to immediate feedback and allowance for repeated attempts at the same problem. If students are scoring better on homework, it would follow that their test scores would also improve, as indicated by a 2013 study by Arora et al.(2013), in which undergraduate engineering students enrolled in a statistics course completed different media homework assignments. Homework scores were recorded as well as test scores. Regardless of the media type, positive correlations were seen between homework scores and test scores, where students scoring higher on
homework were likely to see higher test scores than their peers. In addition, these data demonstrate that students who completed their homework online scored significantly higher on tests.

Many studies have also supported the use of WBHW to increase student learning in large undergraduate courses. A 2011 study by Arasasingham et al. concluded that the use of *Mastering Chemistry* by Pearson in an introductory undergraduate chemistry course resulted in increased final exam scores as compared to students that did not participate. *Mastering Chemistry* is used in conjunction with Pearson’s college chemistry textbooks. It allows professors to assign practice problems and tutorials with molecular animations, which guide students in their study of course content. Likewise, two independent studies in large chemistry classes showed similar positive correlations to exam scores using *Mastering Chemistry* and *Sapling Learning* respectively (Eichler & Peeples, 2013; Parker & Loudon, 2013). While these studies provide support for the use of online homework, in all three cases the use of homework was compared to students not completing homework at all. Therefore, they do not provide evidence that online homework is any more beneficial than traditional pen and paper homework. In studies comparing WBHW to traditional homework in other introductory undergraduate science and math courses, no significant differences have been found (Allain & Williams, 2006; Bonham et al., 2003; Cheng et al., 2004; Demerci, 2010; Kodippili & Senaratne, 2008). However, no studies have previously addressed whether WBHW might provide advantages over traditional paper homework for high school students learning chemistry, a subject that benefits from interactive web-based animations.

**Design of Study**

To further the current research on the topic of WBHW for chemistry, I tested the effectiveness of online learning tutorials as reinforcement of content learned in class by comparing student
learning gains with those of other students who completed the same activity on paper. It was intended that this homework activity serve as practice for the students. For use in this study, web-based homework (WBHW) systems were defined by the parameters used by Bonham (2003) discussing the use of WBHW in the college physics classroom. A WBHW system is one that can be accessed from any standard browser and internet connection, uses a password to authenticate users, delivers assignments to students and receives their answers, grades student work automatically, and keeps a permanent record of the student scores that the instructor can record and access later (Bonham et al., 2003). The WBHW system used in my study was produced by Pearson to accompany the book *Pearson Chemistry* (Wilbraham et al., 2012). Such programs offer many possible benefits to both the teacher and student including: immediate feedback, automatic grading and grade recording, increased computer literacy, additional practice for students, accurate measures of student learning. Disadvantages may include: less consideration being given to student work, fewer organizational skills are practiced by the student, teacher may have difficulty identifying student problem spots, trial-and-error method may be used by students, and the correct answer may be emphasized over the process used to determine the answer (Mendicino et al., 2009). It was anticipated that this intervention would benefit all students because these assignments are in compliance with the following definition of practice as defined by Beesly and Apthorpe, “In order to impact learning, practice must be overt, be ordered appropriately, and include adjustment to feedback” (Beesley & Apthorp, 2010). It was predicted that the students completing WBHW would show significantly greater learning gains than those completing the assignment on paper because the online homework allows students to view animations of processes at the molecular level, as well as providing immediate feedback. The basic progression of the experimental design for a typical chemistry unit is shown in Figure 1.
To determine whether the use of WBHW is beneficial, students were split according to section into two different test groups labeled group A and group B. Both groups received the same classroom instruction on the topic of study. Prior to classroom instruction, all students completed a pre-test composed of approximately 20 multiple-choice problems (see appendix A). Throughout the unit both groups were given homework assignments to reinforce concepts taught in class. Group A completed the activity on paper, while group B used the computer, however, the content was identical. Students completed the unit of study, performing labs or demos as well as in-class problem sets. Upon completion of the unit each student took a post-test that was identical to the pre-test and scores were compared. During the next unit, group A functioned as the experimental group (using WBHW) while group B was the control (using paper).
METHODS AND MATERIALS

Definition of Study Population

The research for this study was conducted in a K-12 private co-educational day school in Baton Rouge, Louisiana. The school serves 738 students including 300 students in the Upper School (grades 9-12). A total of 62 students in grades 9-12 enrolled in four sections of Chemistry were included in the research study. The 62 students were comprised of two freshman, 43 sophomores, 14 juniors and three seniors. The classes were of mixed grade level due to a high number of transfer students, four repeat students and students following different course progressions through the required science courses. The course is taught at a 10th grade level. Of the 62 students, 28 are males and 34 are females, 48 students are white, 12 are African American, and two are Hispanic (Table 2).

Table 2. Demographic breakdown of school, upper school (grades 9-12) and study participants.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>White</th>
<th>Black</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-12</td>
<td>49.9%</td>
<td>50.1%</td>
<td>85%</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>9-12</td>
<td>53%</td>
<td>47%</td>
<td>82%</td>
<td>13%</td>
<td>5%</td>
</tr>
<tr>
<td>Study Participants</td>
<td>45.2%</td>
<td>54.8%</td>
<td>77.4%</td>
<td>19.4%</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

Of the 62 participating students, 32 of them received classroom and testing accommodations for learning differences. Differences included dyslexia, dysgraphia, generalized learning disorder, and attention deficit hyperactivity disorder. These students received extended time and out of class testing. Students were allowed these accommodations when completing pre and post-test assessments. No students received free or reduced lunch. In compliance with the requirements for exemption from institutional oversight, all students in the survey signed child assent forms and
Development of Instruments

To measure learning gains, students participating in the study completed pre and post-tests for each unit of study. Pre and post-tests were created using questions from the ExamView question bank which accompanies the book Pearson Chemistry (Wilbraham et al., 2012). Pre-tests consisted of approximately 20 multiple choice and free response questions applicable to the unit of study. Post-tests consisted of the same 20 questions embedded into the unit test given as part of the high school chemistry class. Pearson Chemistry and the accompanying ExamView are both aligned with the Next Generation Science Standards (NGSS Lead States, 2013). Because these are national standards indicating what a student should know and be able to do after a high school chemistry class, the questions from the test bank are valid for determining learning gains of high school chemistry content.

Student participants were separated into two different groups (Groups A and B) based on class period (Table 3), and then subjected to either web-based homework (treatment) or paper-based homework (control). Students using web-based homework completed learning tutorials online as homework. The tutorials were produced by Pearson to accompany the book Pearson Chemistry and can be found on their online learning site at www.successnetplus.com (see appendix C). Homework assigned from this website consisted of multiple types including: kinetic art, chemistry tutorial, and chapter problem sets. Kinetic art assignments require the students to look at a small number of computer-animated models while it recites the steps aloud, or it allows the student to read about what they are seeing. After they view all of the images, the student is given three to five questions to
answer as a check for understanding. Student answers were recorded and sent to the teacher for grading. The chemistry tutorial assignments demonstrate how to solve a specific type of math-based problem while reciting aloud the steps to the student and showing the math involved. After the student views the example they are given a similar problem to solve themselves. The students receive immediate feedback when working the sample problem, but are not given any direction as to why they are correct or incorrect. Chapter problem sets give the students a series of review questions from the chapter. Teachers can set a threshold score that the student must achieve to complete the homework. Students receive immediate feedback from their answers, but do not receive instruction on how to complete the problems they get wrong.

Students in the control group completed paper assignments that correspond to the WBHW given to the treatment group. To ensure that all students received the same content, the paper homework had identical images and problems. The paper homework was created by taking screen shots of the WBHW from Pearson, and copying the images for students to review at home (see appendix D). The paper assignments included the same follow up questions as the WBHW, and were turned in to the teacher the following day for grading. One difference not accounted for is the option for students to have the text read aloud to them that the WBHW offers, but the traditional paper homework does not.

Collection of Data

This study was conducted during the fall semester of the 2014/15 school year. Students were split into two groups of 32 (Group A) and 30 (Group B) students by class period. Information was collected about each student including GPA, grade level, repeating status and diagnosis of learning disabilities. Students were first exposed to the test parameters during the second unit of the year.
covering chapter 2 *Matter and Change*. In this unit all students took a pre-test and post-test, but these scores were not included in the study data. This allowed students to practice testing and complete homework both online and on paper. Following the first unit, students continued to take pre- and post-tests, however they completed the homework either online or on paper for the entirety of the unit. After the first unit, students that had completed WBHW then were assigned homework on paper and vice-versa.

Table 3. Assignment of control and treatment group by unit of study.

<table>
<thead>
<tr>
<th>Group A (class periods 4, 8 32 students)</th>
<th>Group B (class periods 5, 6 30 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control- paper homework</td>
<td></td>
</tr>
<tr>
<td>4- atomic structure</td>
<td>3- scientific measurement</td>
</tr>
<tr>
<td>6- periodic table</td>
<td>5- electrons in atoms</td>
</tr>
<tr>
<td>Treatment- web-based homework</td>
<td></td>
</tr>
<tr>
<td>3- scientific measurement</td>
<td>4- atomic structure</td>
</tr>
<tr>
<td>5- electrons in atoms</td>
<td>6- periodic table</td>
</tr>
</tbody>
</table>

Students received identical classroom instruction, labs and activities. Only the medium of the homework completion varied.

Table 4. Traditional and WBHW assignments during each unit of study. (KA=kinetic art; CT= chemistry tutorial; PS=problem set).

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 KA</td>
<td>States of Matter</td>
</tr>
<tr>
<td>2.2 KA</td>
<td>Distillation</td>
</tr>
<tr>
<td>3.1 CT</td>
<td>Significant Figures in Multiplication and Division</td>
</tr>
<tr>
<td>3.3 CT</td>
<td>Using dimensional analysis, using density as a conversion factor, converting ratios of units</td>
</tr>
<tr>
<td>3.3 KA</td>
<td>Conversion Factors</td>
</tr>
<tr>
<td>4.2 KA</td>
<td>Cathode Ray / Gold Foil Experiments</td>
</tr>
<tr>
<td>4 PS</td>
<td>Chapter Problem Set</td>
</tr>
<tr>
<td>5.1 KA</td>
<td>Electron Orbitals</td>
</tr>
<tr>
<td>5.2 CT</td>
<td>Writing electron configurations</td>
</tr>
<tr>
<td>6.2 CT</td>
<td>Using energy sublevels to write electron configurations</td>
</tr>
<tr>
<td>6.2 KA</td>
<td>Periodic table tour</td>
</tr>
<tr>
<td>6.3 KA</td>
<td>Trends in the periodic table</td>
</tr>
<tr>
<td>6 PS</td>
<td>Chapter Problem Set</td>
</tr>
</tbody>
</table>
Student pre-test and post-test scores were recorded for units 3-6. Group A served as the control for units 3 and 5 receiving paper homework, and as the experimental group for units 4 and 6 receiving online homework assignments. Group B received the opposite homework assignments. Prior to each unit all students completed identical pre-tests. Students absent on the date of the pre-test were not required to make up the test and were omitted from the data collection for that unit. No students were excused from the post-test, as it also served as the unit test for the course. In addition to student test scores, information on student completion of homework was collected.

Upon completion of all four units, students were issued two student attitude surveys. The first comprehensive survey was used to determine student attitudes towards homework and its use in the high school chemistry classroom (see appendix E). Survey questions were adapted from the Student Assessment of Learning Gains (SALG) questionnaire (Seymour et al., 2000), which was designed to rate student perception of gains in learning, skills and attitudes based on specific classroom instruction. The survey was modified to ask specifically about the use of WBHW and paper-based homework. In addition, students completed a seven question teacher generated survey to assess their attitude towards paper and web-based homework assignments (see appendix F).

Analysis of Data

Student test scores were recorded for each unit as a number of points earned on both the pre-test and post-test assessments. These scores were then used to calculate normalized learning gains for each student using the formula:

$$nLG = \frac{(post\ test - pre\ test)}{(total\ score\ possible - pre\ test)} \times 100$$

Upon completion of the study, each student could have up to four normalized learning gains (one for each unit). Of these four scores it was expected that each student would have two control scores and
two experimental scores. Students that did not complete homework in one or more unit had that score labeled as a “no homework” learning gain. This allowed for comparison of individual student learning gains when completing homework online or on paper. In many cases it also allowed for the comparison of individual learning gains in three categories with the addition of a “not completing the homework” group. Due to absences, many students did not have all four scores. In these cases students were either compared in only two of the three possible categories or were omitted. After omitting students with missing or adjusted categories, 16 students had normalized learning gains in all three categories (WBHW, paper homework, and no homework).

In addition to comparing individual student learning gains for different units, learning gains were compared within units of study. In this case the normalized learning gains of all students completing homework online for a given unit were averaged and compared to the normalized learning gains of students completing homework on paper for the same unit. Scores for students that did not complete the homework were again removed from the control and experimental groups and they created their own “no homework” group.

Student normalized learning gains were compared across experimental, control, and no homework groups with one-way analysis of variance (ANOVA) followed by post-hoc tests for pairwise comparisons. Two-way ANOVA was used to test for differences in learning gains among homework types for different units of study, and for differences in student gender and ethnicity. Linear regression analyses were used to test for relationships between normalized learning gains and GPA. Fischer’s exact test was used to determine significance in homework completion when assigned by traditional or electronic means. All statistical tests were done using Graph Pad Prism software.
RESULTS

Comparison of Normalized Learning Gains

To compare the learning gains of students completing their homework via different methods, the average learning gains of each method were calculated (Table 5). A one-way ANOVA, with Geisser-Greenhouse correction was then used to test for significant differences among all three methods. While there was no statistical difference between the average learning gains of students that completed WBHW and those that completed homework on paper, students that completed their homework (WBHW and traditional) had greater learning gains than those that did not (p=0.0024, F=6.323) (Figure 2).

Figure 2. Average normalized learning gains (%) of four combined units of chemistry study, graphed with standard error of the mean when completing homework traditionally (on paper, n=60), electronically (WBHW, n=42) or not at all (n=35). (*) indicates significant difference from both traditional and electronic methods at p<0.05.)
Table 5. Average of all students normalized learning gains across all units when completing different types of homework.

<table>
<thead>
<tr>
<th></th>
<th>Traditional</th>
<th>WBHW</th>
<th>No HW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Normalized</td>
<td>56.01</td>
<td>56.19</td>
<td>38.21</td>
</tr>
<tr>
<td>Learning Gain (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>30.26</td>
<td>20.84</td>
<td>21.96</td>
</tr>
<tr>
<td>N</td>
<td>60</td>
<td>42</td>
<td>35</td>
</tr>
</tbody>
</table>

Comparisons between Units

After observing no statistical difference between the two types of homework methods when averaging all four units together, each unit was examined separately (Table 6). When doing so it was confirmed that regardless of the material being studied, the type of homework completion (WBHW v. traditional) does not affect student learning gains (2-way ANOVA, by unit p=0.095, F (3,207) =2.188, by type of homework p=0.0001, F (2,207) =12.20) (Figure 3), unit x homework type interaction p=0.6545.) (Table 6, Figures 3&4)

Table 6. Average normalized learning gains (%) of students completing different methods of homework for four units of study.

<table>
<thead>
<tr>
<th></th>
<th>Unit 3</th>
<th>Unit 4</th>
<th>Unit 5</th>
<th>Unit 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>50.77 (n=31)</td>
<td>56.27 (n=28)</td>
<td>67.27 (n=18)</td>
<td>54.96 (n=19)</td>
</tr>
<tr>
<td>Electronic</td>
<td>61.28 (n=17)</td>
<td>55.56 (n=21)</td>
<td>56.46 (n=17)</td>
<td>46.02 (n=14)</td>
</tr>
<tr>
<td>No HW</td>
<td>38.51 (n=14)</td>
<td>25.56 (n=21)</td>
<td>45.39 (n=22)</td>
<td>21.29 (n=12)</td>
</tr>
</tbody>
</table>
Figure 3. Average normalized learning gains of students when completing different types of homework for four separate units of chemistry study graphed with standard error of the mean. (* Indicates significant difference from both traditional and electronic methods within each unit at p<0.05).

In all four units, learning gains were lower when students did not complete their homework at all compared to when they did using either traditional or electronic methods (Figure 3). The differences appear more pronounced in units four and six, however this may be misleading. In both of these units, fewer students failed to complete their homework resulting in low sample sizes in the no homework category.

Figure 4 shows the learning gains over the course of the study for each type of homework completed. Upon seeing the data displayed over time, it may be logical to assume that traditional homework caused students to improve throughout the year, where completing homework in other methods did not. This trend of improvement is only seen from units 3 through 5 and only in students
that completed homework on paper. However, there is not enough data at this time to make such a conclusion.

Figure 4. Average normalized learning gains of students completing different types of homework over four chemistry units graphed with standard error of the mean. (* Indicates significant difference from both traditional and electronic methods at p<0.05).

Subsets of the Study Population

In addition to confirming that the content does not affect the learning gains, student scores were analyzed to determine if the gender or ethnicity of the student had any effect on homework type preference and learning gains. Normalized learning gains were divided first by gender and then by ethnicity and compared using a two-way ANOVA. Comparisons of student learning gains confirmed that there was not a significant difference in learning gains between male and female students, but for both genders, students that did not complete homework had significantly lower learning gains (2-way ANOVA, by gender p=0.5945, F (1, 126) =0.2848, by type of homework p=0.0018, F (2, 126) =6.630, gender x homework type interaction p=0.6571)) (Figure 5).
Figure 5. Average normalized learning gain of males and females completing different types of chemistry homework, graphed with standard error of the mean. (* Indicates significant difference from both traditional and electronic methods at p<0.05).

A 2-way ANOVA of the data separated by ethnicity confirmed similar results. In this case there was not a significant difference seen between the scores of Caucasian and minority students, but in both cases students who did not complete homework had significantly lower learning gains (2-way ANOVA, by ethnicity p=0.3722, F (1, 174)=0.8005, by type of homework p=0.0055, F (2, 174)=5.357, ethnicity x homework type interaction p=0.6221) (Figure 6).

Figure 6. Average normalized learning gain of Caucasian and other ethnicity students completing different types of chemistry homework graphed with standard error of the mean. (* Indicates significant difference from both traditional and electronic methods at p<0.05).
Relationships between Learning Gains and GPA

While gender and ethnicity of the student did not have an effect on learning gains, there was a positive relationship between student GPA and learning gains (Figure 7).

Figure 7. Average normalized learning gains of all chemistry homework types compared to GPA shows a significant positive relationship (linear regression $R^2=0.306$, $p<0.0001$, significant deviation from zero, $n=58$). Upper and lower lines represent the 95% confidence bands.

Student’s average learning gain for all four units (regardless of homework-type completion) was plotted against their GPA prior to the start of the study (i.e. the beginning of the school year). A linear regression shows that there is a strong positive relationship between a student’s GPA and their learning gain, however as seen in the graph, a number of data points fall outside of the 95% confidence band (Figure 7). To get a clearer picture of these data, student’s scores were separated by homework type completion and re-plotted (Figure 8).

In examining the relationship between GPA and learning gains of the three homework types separately, it is seen that there are positive relationships between GPA and normalized learning gain when students complete homework either on paper (linear regression, $R^2=0.1419$, $p=0.0042$, $n=56$) or on the web (linear regression, $R^2=0.2538$, $p=0.0011$, $n=39$) (Figure 8A, B). Students with a higher GPA prior to the course are likely to gain more knowledge regardless of the type of homework they
complete. However, there is no such correlation seen when students do not complete their homework (linear regression, $R^2=0.078$, $p=0.1200$, $n=32$) (Figure 8C).

![Figure 8. Relationship between GPA and normalized learning gains (nLG) of students completing chemistry homework by traditional (A) or electronic (B) means, and those not completing homework (C). Upper and lower lines represent 95% confidence bands. There was a significant positive relationship between nLG and GPA for students completing both traditional and electronic homework, but not for those students that did not complete homework.]

**Effects on Homework Completion**

Due to significant differences in learning gains between students completing and not completing homework, it is useful to determine whether students are more likely to complete one type of homework compared to another. Therefore, percentages of students that completed assigned homework on paper or on the web were examined for all four units. It is interesting that in all four units, students were more likely to complete homework when it was assigned on paper, rather than the electronic WBHW. The greatest difference was in unit three, in which 100% of students that were assigned the homework on paper turned in the assignment compared to only 48% of students that were assigned the homework on the internet.
To further support the conclusion that students are more likely to complete their homework when assigned on paper, the total number of assignments completed on paper and on the web was summed and analyzed using a contingency table. Fischer’s exact test was used to determine that students more often complete their homework when assigned on paper compared to electronically (Fischer’s exact test, two-tailed, p = 0.0001).

Table 7. Total number of chemistry homework assignments completed when assigned on paper or on the web, n=124 per type of homework. (* indicates significant difference in homework completion based on type of homework)

<table>
<thead>
<tr>
<th>Type</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>107*</td>
<td>17</td>
</tr>
<tr>
<td>Electronic</td>
<td>80</td>
<td>44</td>
</tr>
</tbody>
</table>

**Student Attitudes**

Upon completion of the study students were given a survey comprised of 33 items modified from the SALG (Seymour et al., 2000). The results of the survey, while not definitive seem to indicate a general preference of students to complete homework via traditional methods (Table 8). 65% of
students reported that traditional homework resulted in good to great learning gains, while only 10% of students reported the same for WBHW. In addition to asking about how the students perceive their learning, students were asked how likely they were to complete homework, and how likely they were to do so without unauthorized aid. Only one student reported that they were never or rarely likely to complete traditional homework compared to 16 students reporting the same response to WBHW. Also there was a 17% increase in students that reported never or rarely completing their homework with integrity when using WBHW compared to traditional homework (Table 8).

Table 8. Selected questions from the student attitude survey indicating the % of students that answered each response.

<table>
<thead>
<tr>
<th>How much have the following aspects of the course helped your learning</th>
<th>None</th>
<th>Little</th>
<th>Moderate</th>
<th>Good</th>
<th>Great</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBHW</td>
<td>23%</td>
<td>41%</td>
<td>26%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>Traditional HW</td>
<td>2%</td>
<td>34%</td>
<td>37%</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>Timely feedback</td>
<td>10%</td>
<td>13%</td>
<td>35%</td>
<td>31%</td>
<td>12%</td>
</tr>
<tr>
<td>Detailed Feedback</td>
<td>2%</td>
<td>13%</td>
<td>36%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Practice in Class</td>
<td></td>
<td>6%</td>
<td>40%</td>
<td>54%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How likely are you to complete the following (or how often have you completed the following?)</th>
<th>Never</th>
<th>Rarely</th>
<th>Moderate</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Homework</td>
<td>2%</td>
<td>4%</td>
<td>37%</td>
<td>58%</td>
<td></td>
</tr>
<tr>
<td>WBHW</td>
<td>4%</td>
<td>27%</td>
<td>17%</td>
<td>32%</td>
<td>21%</td>
</tr>
<tr>
<td>Traditional homework on your own with integrity, without outside help or the use of additional resources</td>
<td>8%</td>
<td>32%</td>
<td>44%</td>
<td>17%</td>
<td></td>
</tr>
<tr>
<td>WBHW homework on your own with integrity, without outside help or the use of additional resources</td>
<td>8%</td>
<td>17%</td>
<td>40%</td>
<td>28%</td>
<td>6%</td>
</tr>
</tbody>
</table>
In conjunction with the 33-question student attitude survey the students also answered seven questions written by the teacher, and reported their opinions using a Likert scale ranging from strongly disagree to strongly agree. The results of this survey indicate that a minority (37%) of students prefer WBHW, indicating that the majority of students prefer traditional homework. In addition, only 14% of students feel they learn more from WBHW, however 57% of students report learning more from computer animations than still pictures (Table 9).

Table 9. Positive responses to teacher generated student opinion survey.

<table>
<thead>
<tr>
<th>Statement</th>
<th>% of students that agree or strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I prefer to complete my homework on the computer rather than on paper</td>
<td>37.25%</td>
</tr>
<tr>
<td>I am more likely to complete my homework if it assigned on the computer</td>
<td>31.37%</td>
</tr>
<tr>
<td>I learn more when completing my homework on the computer</td>
<td>13.75%</td>
</tr>
<tr>
<td>I learn more when watching animations that move than looking at still pictures</td>
<td>56.90%</td>
</tr>
<tr>
<td>I am more likely to cheat if the homework is assigned on the computer</td>
<td>15.69%</td>
</tr>
<tr>
<td>I learn from the immediate feedback of online homework programs</td>
<td>15.69%</td>
</tr>
<tr>
<td>I perform better on assessments if I have completed all of the homework assigned throughout the unit</td>
<td>58.82%</td>
</tr>
</tbody>
</table>
DISCUSSION

Summary of Results

This study demonstrates that the type of homework completed (web-based vs traditional paper) does not affect student’s learning gains in a high-school chemistry course, however the completion of homework in some form does significantly improve student’s learning gains compared to not completing homework at all. This is important because it indicates that through increased time spent on homework and increased practice of skills students can increase their learning more than if they limit their time with material to the time spent in the classroom. This is consistent with previous studies linking time spent on homework to increased learning gains (Beesley & Apthorp, 2010; Demerici, 2010; Maltese, Tai, & Fan, 2012). It is also of note that these findings are consistent regardless of student gender or ethnicity. While the type of homework completed does not seem to influence learning in the context of this chemistry course, it is evident that students are more likely to complete homework if assigned on paper. This is supported by both the higher percentage of students that completed homework assignments on paper compared to online, and the student attitude survey, in which only 31% of students said they were more likely to complete their homework on the computer. If the goal is to have students completing homework, these findings would then lead to the conclusion that assigning homework on paper would increase the amount of completion and thus result in higher learning gains for the students.

While the results of this study do not indicate that there is a benefit to online homework, many studies report positive results in learning gains or in student perception (Demerici, 2007; Peng, 2009; Richards-Babb et al., 2001). The lack of positive results may be explained by a variety of factors. Students were new to using this computer-based program and unfamiliarity with the
program may have caused anxiety or distraction from the intended learning target. For homework to be the most effective, a student should be focused on the task and distractions should be minimized (Maltese et al., 2012; Xu, 2010). In a study on homework distraction by Xu (2010), it was indicated that a student’s distraction can come from various sources, but that increased access to technology may cause more distraction than previous sources of distraction. This may explain why the learning gains of students completing WBHW were not seen to be significantly different, and it is suggested that more research be done to determine if student distraction is increased when completing WBHW as compared to traditional methods.

**Recommendations to Educators**

Upon completion of this study it is recommended that high school chemistry classes continue to assign homework as a regular part of the course. It is especially useful in the chemistry classroom because homework tends to be practice-type questions, and increased practice time is shown to have positive effects on student learning (Beesley & Apthorp, 2010; Demerci, 2010; Maltese, Tai, & Fan, 2012). However this study raises a lot of questions pertaining to how homework is assigned in high school classes, and the utility of online versus traditional paper methods may need to be evaluated on a subject by subject basis.

To promote the completion of homework in high school, teachers must encourage intrinsic motivation and autonomy of learning. Students who are intrinsically motivated and able to self-regulate their learning show greater success in future education (Kackar et al., 2011; Maltese et al., 2012; Zimmerman & Kitsantas, 2005). To encourage homework completion it is important to recognize trends in homework completion. According to a study conducted by Kackar et al. (2011), students spend between 2.2 and 3.7 hours completing homework each day, with high school
students only reporting about 30 minutes more per day than middle school students. They further report that while high school students’ homework loads increase they are less likely to complete their homework (Kackar et al., 2011). Older students (high school) also prefer to complete their homework alone rather than collaboratively which supports the developmental need for independence and autonomy. Further research is needed to determine if WBHW can be used to promote self-efficacy of the student and if homework should be catered to student behaviors, or if behaviors should be modified to the type of work assigned.

To design homework that students are likely to complete it is important to note some factors that affected student’s decision to complete homework or not. Some students reported a preference for paper homework because they were able to complete it in other high school courses, rather than having to take it home. They felt that completing paper homework was more convenient than using their computers. In addition, students also reported a number of barriers to completing the WBHW. The specific software used in this study was difficult for the students to navigate, many complained of having “too many clicks” involved in opening the homework. In addition, students had to have the correct flash player installed on their computers, and had to ensure certain pop-up blockers were turned off. Even if students were able to successfully log into the program to set up the initial course they often would forget their log-in or password, or confuse the website with similar sites used for other courses. It is important for educators to be aware of these potential problems associated with WBHW and consider if it would be beneficial in their classrooms.

While my study did not show any significant differences in learning gains associated with the method of homework completion, it is important to note that there are some benefits to either type of homework assigned. According to the student attitudes survey, students are more likely to
complete and feel they learn better when assigned traditional homework. This, along with the decreased cost of paper homework make a strong case for assigning traditional homework. In addition, traditional homework allows the teacher to provide detailed feedback, provided the teacher has the time and resources to do so. In schools where funding for electronic homework is not available, the students should not be at a disadvantage.

Even while there are benefits to traditional homework there are other benefits to WBHW. Students feel that they learn from the computer animations and like the immediate feedback given. In schools that do have the funds, and the amount of feedback from the teacher is limited due to large class sizes, WBHW can be a useful alternative. One factor that contributes to learning associated with homework is the student’s attitude toward the assignment (Maltese et al., 2012; Richards-Babb et al., 2001; Trautwein, 2007; Zimmerman & Kitsantas, 2005). Students in the study population often expressed their dislike of the specific WBHW suite chosen, but expressed liking to complete their math homework through a different program. This is interesting because for many students it is the second or third year they have been using the same math program, while it was only the first time they have used WBHW in science. This may suggest that learning gains and student attitudes when using WHBH may increase over time, as they become more familiar with the program. Familiarity with WBHW systems has been identified as a factor which contributes to the success of the specific homework program (Demerci, 2007; Richards-Babb et al., 2001).

Regardless of the type of homework completed it is important that educators assign homework with extreme intention. Homework assignments can be a valuable tool to increase learning, however they should be relevant to the learning in class and should be returned with detailed feedback to guide the student’s learning.
REFERENCES


APPENDIX A
SAMPLE QUESTIONS FROM UNIT FOUR PRE-TEST

1. A sample of copper with a mass of 63.5g contains $6.02 \times 10^{23}$ atoms. Calculate the mass (in grams) for one atom of copper.

2. The nucleus of the atom contains _____. (Circle all that apply)
   a. protons
   b. electrons
   c. neutrons
   d. photons

3. The mass of the electron _____. (Circle the correct answer)
   a. is equal to the mass of the proton
   b. is equal to the mass of the neutron
   c. is 1840 times less massive than a neutron
   d. is 1840 times more massive than a proton

4. Which of the following is not a part of Dalton’s atomic theory?
   a. All elements are composed of atoms.
   b. Atoms of the same element are alike.
   c. Atoms are always in motion.
   d. Atoms that combine do so in simple whole-number ratios.

5. The sum of the protons and neutrons in an atom equals the
   a. atomic number.
   b. number of electrons.
   c. atomic mass.
   d. mass number.

6. An atom of an element with atomic number 48 and mass number 120 contains
   a. 48 protons, 48 electrons, and 72 neutrons.
   b. 72 protons, 48 electrons, and 48 neutrons.
   c. 120 protons, 48 electrons, and 72 neutrons.
   d. 72 protons, 72 electrons, and 48 neutrons.

7. How do the isotopes hydrogen-2 and hydrogen-3 differ?
   a. Hydrogen-3 has one more electron than hydrogen-2.
   b. Hydrogen-3 has two neutrons.
   c. Hydrogen-2 has three protons.
   d. Hydrogen-2 has no protons
APPENDIX B
IRB APPROVAL, CHILD ASSENT AND PARENTAL CONSENT

ACTION ON EXEMPTION APPROVAL REQUEST

TO: Molly Shuman
    Biological Sciences
FROM: Dennis Landin
      Chair, Institutional Review Board
DATE: July 2, 2014
RE: IRB# E835
TITLE: The effectiveness of online homework tutorials as compared to traditional homework in the high school chemistry classroom
Review Date: 7/2/2014
Approved X Disapproved
Approval Date: 7/6/2014, Approval Expiration Date: 7/6/2017
Exemption Category/Paragraph: 1
Signed Consent Waived?: No
Re-review frequency: [three years unless otherwise stated]
LSU Proposal Number (if applicable) ______
Protocol Matches Scope of Work in Grant proposal: (if applicable) ______
By: Dennis Landin, Chairman ____________________________

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, similarity with, and adherence to the ethical standards of the Belmont Report, and LSU’s Assurance of Compliance with DHHS regulations for the protection of human subjects.
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submission of a termination report), prior to the approval expiration date, upon request by the IRB Office (irrespective of when the project actually begins), notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
8. SPECIAL NOTE:
    *All investigators and support staff have access to copies of the Belmont Report, LSU’s Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or available on our World Wide Web site at http://www.lsu.edu/irb
Child Assent

I, _______________________________________________ agree to participate in a study that will help Ms. Shuman determine if the use of online learning tutorials will help increase student learning. I understand that during this study, I will participate by taking assessments, competing online or paper learning tutorials and by completing surveys. I understand that I can withdraw from participating in this study at any time without disciplinary or academic penalty.

Student’s Signature: ___________________________ Age: _________ Date: __________

Witness*: ________________________________ Date: __________

*N.B. Witness must be present for the assent process, not just the signature by the minor

Dr. Dennis Landin, Chairman
Institutional Review Board
Louisiana State University
130 David Boyd Hall
P: 225.578.8692
F: 225.578.5983
www.lsu.edu/irb
irb@lsu.edu
Parental Permission

PROJECT TITLE: Determining the effectiveness of online learning tutorials as compared to pen and paper tutorials.

PERFORMANCE SITE: The Dunham School
11111 Roy Emerson Dr.
Baton Rouge, LA 70810

INVESTIGATORS: The following investigators are available for questions about this study,
Monday-Friday 9:00 am-3:00 pm
Dr. Karen Maruska (225) 578-1738
Molly Shuman (614) 746-7263

PURPOSE OF THE STUDY: The purpose of this study is to determine whether the implementation of online learning tutorials results in greater learning gains than using paper learning tutorials.

INCLUSION CRITERIA: Students in 9th-11th grade enrolled in chemistry with Molly Shuman

DESCRIPTION OF STUDY: During the 2014-2015 school year the investigator will administer learning tutorials as reinforcement of previously taught content. The reinforcement tutorial will be administered either via the computer or on paper. All students will receive identical information whether completing the tutorial online or on paper. Those students using computers for the first unit will receive the tutorial on paper for the following unit and vice-versa. All students will take a pre-test prior to the reinforcement and a post-test at the completion of the unit of study. Learning gains will be calculated from the test scores. The learning gains of students that completed the tutorial online will be compared to the learning gains of those students that completed the tutorial on paper.

BENEFITS: It is anticipated that the investigator will be able to determine whether using the computer for self-guided learning tutorials is beneficial to student learning. If this is found to be a beneficial teaching method it will be implemented in future courses.

RISKS: There are no known risks associated with participation in this study.

RIGHT TO REFUSE: It is not mandatory that a student subject choose to participate. At any time, either the subject may withdraw from the study or the subject’s parents may withdraw the subject from the study. Non-participation in this study will have no impact on student’s final grades or assessments throughout the duration of the school year.

PRIVACY: The records of participants in this study include, but are not limited to test scores and attendance, which may be reviewed by investigators. Also, results of the study may be published, but no names or other identifying information will be disclosed in publication. All subjects’ identities will remain confidential unless otherwise advised by law.

FINANCIAL INFORMATION: There is no cost for participation in this study, nor is there any compensation to the student subjects and/or their representatives for participation.

SIGNATURES: This study has been discussed with me and all questions have been answered. I may direct additional questions regarding study specifics to the primary and/or co investigators. I will allow my child to participate in the study described above and acknowledge the investigator’s obligation to provide me with a signed copy of this consent form.

Parent Signature: _______________________________ Date: ______________

Institutional Review Board Dr. Dennis Landin, Chair 130 David Boyd Hall Baton Rouge, LA 70803
P: 225.578.8692 F: 225.578.5983 irb@lsu.edu lsu.edu/irb
APPENDIX C
SCREEN SHOTS OF WBHW

Electron Orbitals

Solutions to the Schrödinger equation give rise to atomic orbitals. For a given principal energy level greater than 1, there is one s orbital and three p orbitals. Four of the five d orbitals have the same shape but different orientations in space.

This animation shows the s orbitals. First the 1s orbital is shown, then 2s, 3s, and 4s orbitals. What do you observe about the relative sizes of these orbitals?

A jewelry company has announced that they have created gold from reacting copper and carbon in a chemical process. According to Dalton’s atomic theory, is this possible?

A. yes, because atoms of different elements can physically mix together.
B. yes, because all elements contain atoms and gold is an element.
C. no, because chemical reactions are not possible.
D. no, because copper, carbon and gold are all elements, and atoms of one element can never be changed into atoms of another element through a chemical reaction.

Next Question
An experiment requires that each student use an 8.5-cm length of magnesium ribbon. How many students can do the experiment if there is a 570-cm length of magnesium ribbon available?

1. **Analyze**  List the knowns and the unknown.
   
   From the known length of magnesium ribbon, use the appropriate conversion factor to calculate the number of students who can do the experiment.
   
   The desired conversion is length of magnesium $\rightarrow$ number of students.

2. **Calculate**  Solve for the unknown.
   
   The experiment calls for a 8.5-cm length of Mg per student.
   
   Based on this relationship, you can write two conversion factors.
   
   $\frac{8.5 \text{ cm Mg}}{1 \text{ student}}$ and $\frac{1 \text{ student}}{8.5 \text{ cm Mg}}$

   Start dimensional analysis by writing two conversion factors.
APPENDIX D
SAMPLE TRADITIONAL HOMEWORK

P orbitals- the 2px, 2py, 2pz as well as the 3px, 3py, and 3pz orbitals.

S orbitals- The 1s, 2s, 3s and 4s orbitals are shown, what do you notice about the relative sizes of each?

Questions

• How are the s orbitals different from the p orbitals?
• How did the s orbitals change as the principal energy level increased?
• Suppose your friend said, “atomic orbitals are the parts of the atom that contain the electrons.” Why is this statement not correct? How would you correctly explain the relationship between atomic orbitals and electrons?
APPENDIX E  
STUDENT SURVEY ADAPTED FROM SALG

Student survey: Chemistry 2014-2015

As a result of completing **homework online** what gains did you make in the following areas

<table>
<thead>
<tr>
<th>Area</th>
<th>None</th>
<th>Little</th>
<th>Moderate</th>
<th>Good</th>
<th>Great</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying patterns in data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enthusiasm for Chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence in understanding chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comfort level when working with complex ideas</td>
<td></td>
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<td>Willingness to seek help from others with academic problems</td>
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<td>Knowledge and understanding of Language of chemistry</td>
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<td>Knowledge and understanding of Process of chemistry</td>
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<tr>
<td>Ability to understand what information is needed to solve a problem</td>
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<tr>
<td>Ability to divide problems into manageable components</td>
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</table>

As a result of completing **homework on paper** what gains did you make in the following areas

<table>
<thead>
<tr>
<th>Area</th>
<th>None</th>
<th>Little</th>
<th>Moderate</th>
<th>Good</th>
<th>Great</th>
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</thead>
<tbody>
<tr>
<td>Identifying patterns in data</td>
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<tr>
<td>Enthusiasm for Chemistry</td>
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<td>Confidence in understanding chemistry</td>
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<tr>
<td>Comfort level when working with complex ideas</td>
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<td>Willingness to seek help from others with academic problems</td>
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</table>
### How likely are you to complete the following (or how often have you completed the following)

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Moderate</th>
<th>Often</th>
<th>Always</th>
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</thead>
<tbody>
<tr>
<td>Traditional homework</td>
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<tr>
<td>WBHW</td>
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<tr>
<td>Traditional homework on your own with integrity, without outside help or use of additional resources</td>
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<tr>
<td>WBHW homework on your own with integrity, without outside help or use of additional resources</td>
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<tr>
<td>Assigned Readings</td>
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<tr>
<td>Activities in class (labs, demos etc.)</td>
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<tr>
<td>Practice in class</td>
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### How much have the following aspects of the course helped your learning

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Little</th>
<th>Moderate</th>
<th>Good</th>
<th>Great</th>
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<tbody>
<tr>
<td>Online Homework</td>
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<tr>
<td>Traditional Homework</td>
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<tr>
<td>Practice in class</td>
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<tr>
<td>Lecture</td>
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<tr>
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<tr>
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<tr>
<td>Timely feedback (as provided by WBHW)</td>
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<tr>
<td>Detailed feedback from the teacher</td>
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APPENDIX F
TEACHER GENERATED STUDENT ATTITUDE SURVEY

Please answer the following questions as honestly as possible. Your answers will remain anonymous and not affect your grade in the class.

1. **I prefer to complete my homework on the computer rather than on paper**
   - 1= strongly disagree
   - 2=disagree
   - 3=neutral
   - 4=agree
   - 5=strongly agree

2. **I am more likely to complete my homework on the computer than on paper**
   - 1= strongly disagree
   - 2=disagree
   - 3=neutral
   - 4=agree
   - 5=strongly agree

3. **I learn more when completing my homework on the computer than on paper**
   - 1= strongly disagree
   - 2=disagree
   - 3=neutral
   - 4=agree
   - 5=strongly agree

4. **I learn more when watching animations that move than looking at still pictures**
   - 1= strongly disagree
   - 2=disagree
   - 3=neutral
   - 4=agree
   - 5=strongly agree

5. **I am more likely to cheat if the homework is on the computer than on paper**
   - 1= strongly disagree
   - 2=disagree
   - 3=neutral
   - 4=agree
   - 5=strongly agree

6. **I learn from the immediate feedback of online homework programs**
   - 1= strongly disagree
   - 2=disagree
   - 3=neutral
   - 4=agree
   - 5=strongly agree
7. I perform better on assessments if I have completed all of the homework assigned throughout the unit

1= strongly disagree 
2= disagree 
3= neutral 
4= agree 
5= strongly agree

8. Please write a 1-2 paragraph reflection about homework. What do you like about homework online (math XL too) and what do you not like? What motivates you to complete homework? Do you find it important? Do you cheat?
VITA

Molly Shuman was born in Dublin, Ohio in 1988. She attended Dublin City Public Schools until 2006. She then earned a Bachelor’s degree in biology from Wittenberg University in Springfield, Ohio in 2010. She entered the Graduate School at Louisiana State University and Agricultural and Mechanical College in May 2013 and is a candidate for a Masters of Natural Science Degree. Molly has been a science teacher at the Dunham School in Baton Rouge, LA since January of 2011.