

Assessment of Sapling Learning Online Homework Effects on Student Performance

Abstract

The Sapling Learning online homework system is used in many chemistry lecture courses, but its effect on student outcomes has not been assessed previously. A controlled study comparing student performance in a Fall 2014 Chem 51A class using Sapling Learning to one using only textbook homework had been conducted. Students who were assigned online homework through Sapling Learning outperformed their peers who were assigned only textbook homework based on final exam scores, with the largest effect observed for students with lower cumulative GPA scores. The effect disappeared for students with average or above average GPA scores. Survey responses indicated mixed but generally positive attitudes toward homework in general and Sapling Learning specifically. Results of the study will be used to determine whether use of the online homework system should be continued.

Introduction

Inclusion of formative assessments is essential to supporting student learning. Although there are many types of formative assessment, one of the most important tools utilized in STEM fields is the assignment of practice problems as homework. When used appropriately, these homework assignments help students to identify areas of weakness in their understanding and serve as practice runs before higher stakes summative assessments such as midterms and final exams. Unfortunately, the large enrollments of all lower division chemistry lectures preclude the effective use of traditional homework assignments. The time and personnel required to provide any meaningful feedback on homework assignments would be so large as to be prohibitive.

In the last decade technology has advanced to the point where electronic and online homework systems have proliferated. Development of systems that could be effective for organic chemistry courses lagged behind those for other areas because of the highly visual nature of the content and because technology had not advanced enough to allow students to submit answers in the form of drawings.

Beginning in 2008, a few Chem 51 (organic chemistry) lectures at UCI began using Sapling Learning, an online homework system that provided the best homework solution for organic chemistry at that time. Although we have been using Sapling Learning in many of our lectures for six years, no previous concerted effort has been made to assess the efficacy of this online homework system on students learning. A thorough assessment of the effect of Sapling Learning on student performance using two of our Fall 2014 Chem 51A Organic Chemistry lectures.

Learning Objectives

A number of student learning objectives have been identified for Chem 51A previously, and a condensed list is provided below. The proposed assessment will provide evidence to support or refute the efficacy of the Sapling Learning homework system to assist students in achieving these outcomes. Although assessment of student progress on individual learning outcomes is not possible at this time, performance on identical final exams that include questions designed to test the objectives served as a stand-in for overall progress.

- Students will translate between molecular formulas and structural drawings.
- Students will determine molecular structure from spectroscopic data.
- Students will correlate molecular structure with acidity, basicity, electrophilicity, and nucleophilicity.
- Students will use fundamental concepts of thermodynamics and kinetics to predict behavior in chemical systems.
- Students will predict products of and identify appropriate reagents for nucleophilic substitution reactions.
- Students will use knowledge of structure and function to predict mechanisms for substitution reactions.

Study Design

Two sections of Chem 51A, both team-taught by the same faculty, were used in the assessment. Registrar data was used to ensure that both sections were similar in demographics and to examine effects on different population segments. Both sections were taught in an identical manner with the exception of the types of homework assignments. Teaching assistants were assigned to discussion sections for both lecture sections to remove TA effect as a confounding variable. Midterms for both lecture sections were different but as comparable as possible. The classes were given a common final exam at the same time.

Homework assignments for the lectures differed. One section, used as the control section, was assigned only textbook problems as homework. The second section was assigned homework in the Sapling Learning system. Sapling Learning agreed to provide free access for the students in the treatment class for the Fall 2014 term. Both classes were provided with a list of supplementary problems from the textbook. Assigning the supplemental book problems to both sections allowed us to mimic the regular conditions of a class with assigned Sapling problems. Most, if not all, lecture classes provide a list of suggested book problems along with Sapling problems. Data was collected on homework completion rates for individual students in both classes. Additionally, survey data was collected to assess how much time students spent on each type of homework and to gauge their attitudes toward the types of homework. Statistical analysis was conducted to determine whether the use of the Sapling Learning system had a positive effect on student performance. Demographic data collected from the registrar was used to explore effects within varying demographic groups.

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Table 1. Summary of Design

	Treatment Group	Control Group	Notes
Assigned Homework	Sapling homework problems (graded, but only very minor deductions for incorrect responses - multiple tries available)	Assigned book problems (ungraded for content, credit given for completion)	Problems as comparable in number and content as possible.
Additional suggested problems	Small subset of additional suggested book problems	Small subset of additional suggested book problems	Identical for both groups.
TA Assignment	Shared TAs	Shared TAs	TAs assigned to both classes to remove potential confounding variable.
Midterms	Given in class	Given in class	As similar as possible but not identical.
Final Exam	Given at night during finals week	Given at night during finals week	All students given same final at same time.

Study Results

Statistical Analysis

Comparison of demographic information revealed no significant differences between the two class sections with respect to major, gender, ethnicity, or incoming SAT scores. Class exam scores for the control section and the treatment section were compared to elucidate any effect resulting from the online homework. Multiple linear regression analysis demonstrated a robust interaction effect for the introduction of Sapling Learning homework. The statistical analysis results are summarized in Table 2 and Figure 1.

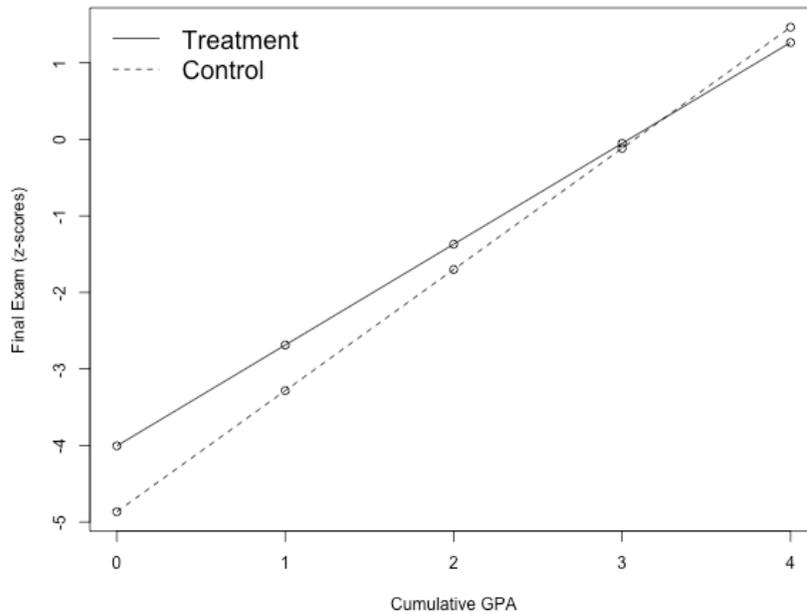
Table 2. Effect of Sapling Learning Homework Grouped by GPA

	GPA = 0	GPA = 1	GPA = 2	GPA = 3	GPA = 4
Control	-4.866	-3.283	-1.7	-0.117	1.466
Treatment	-4.005	-2.687	-1.37	-0.052	1.265
Effect Size	0.861	0.596	0.33	0.065	-0.2
p-value	0.014	0.013	0.012	0.242	0.098

Overall, students in the treatment group with lower incoming GPA scores showed the greatest difference in final exam scores as compared to their counterparts in the control group. Students with the average GPA score of 3.0 and above showed no statistically significant difference in final exam performance as compared to their control group counterparts. The interaction itself is the most important finding. The online homework assignment benefited weaker students (as measured by cumulative GPA) in particular, while not hurting stronger students. This observation is consistent with many other educational intervention studies in which lower performing students benefit most from the intervention in question.

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Figure 1. Control vs Treatment Group Final Exam Performance



In an additional preliminary analysis, midterm exam scores were compared between the treatment and control groups. For midterm 1, treatment students with the average 3.0 GPA outperformed their control counterparts by 0.458 SDs ($p < 0.001$), whereas, treatment students with 4.0 GPA did practically the same as their control counterparts ($SE = 0.39$ SDs, $p = 0.771$). For midterm 2, treatment students with the average GPA outperformed their control counterparts by 0.585 SDs ($p < 0.001$). Moreover, treatment students with 4.0 GPA also outperformed their control counterparts ($SE = 0.274$ SDs, $p = 0.030$). The midterm exams given to each group were not identical, so additional analysis is required to remove any additional effect from differing difficulty levels. With such a large and consistent interaction effect size, however, it is unlikely that any differences in exam difficulty would be large enough to completely negate the effect.

Survey Responses

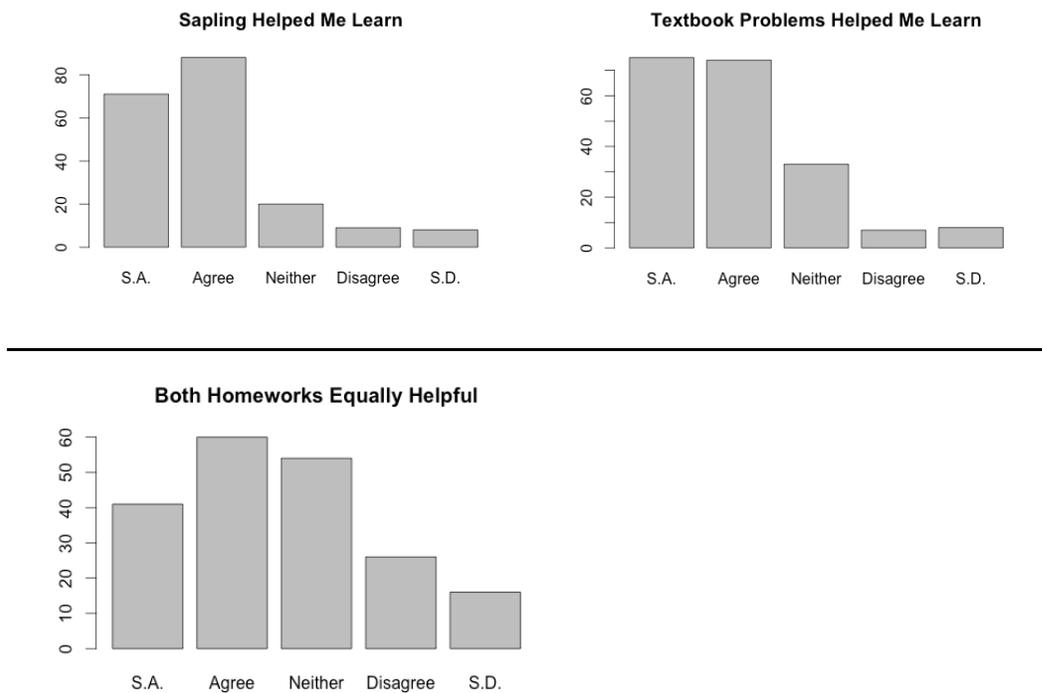
Both groups of students were surveyed regarding their feelings toward and time spent on their respective homework assignments. Comments regarding homework assignments were also solicited. Response rates for each survey varied, with 199 students from the treatment group responding and 261 students from the control group responding. Submissions for individual questions were not required, so the exact number of responses for each question varied slightly. Survey results are summarized below in Figures 2-4.

Among the treatment group, 159 students (81% of question respondents) agreed with the statement, "I think that working Sapling problems helped me learn." The

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same group of students responded favorably (149 students, 76% of question respondents) to the statement, “I think working textbook problems helped me learn.” Additionally, students were asked to rank their agreement with statements comparing the helpfulness of each homework type. For the statements “I think Sapling problems are more helpful than textbook problems” and “I think textbook problems are more helpful than Sapling problems,” the majority of students chose a neutral response. This can be seen most clearly in the responses to the statement “I think textbook problems and Sapling problems are about equally helpful,” where 101 students (51% of question respondents) agreed, 54 students (27% of question respondents) chose a neutral answer, and only 42 students (21% of question respondents) disagreed.

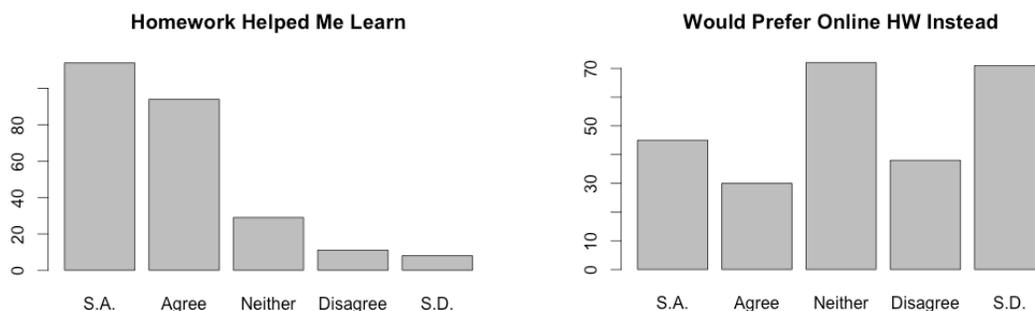
Figure 2. Treatment Group Responses Regarding Helpfulness of Homework



Students in the control group responded favorably to questions regarding their assigned homework (Figure 3). When asked to rank their agreement with the statement “I think working assigned textbook problems helped me learn,” 208 students (82% of question respondents). When asked whether they would have preferred being assigned online homework instead of textbook homework, responses varied widely. A total of 75 students (30% of question respondents) agreed while 109 students (43% of question respondents) disagreed. The remaining 27% of students indicated a neutral response.

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Figure 3. Control Group Responses Regarding Helpfulness of Homework

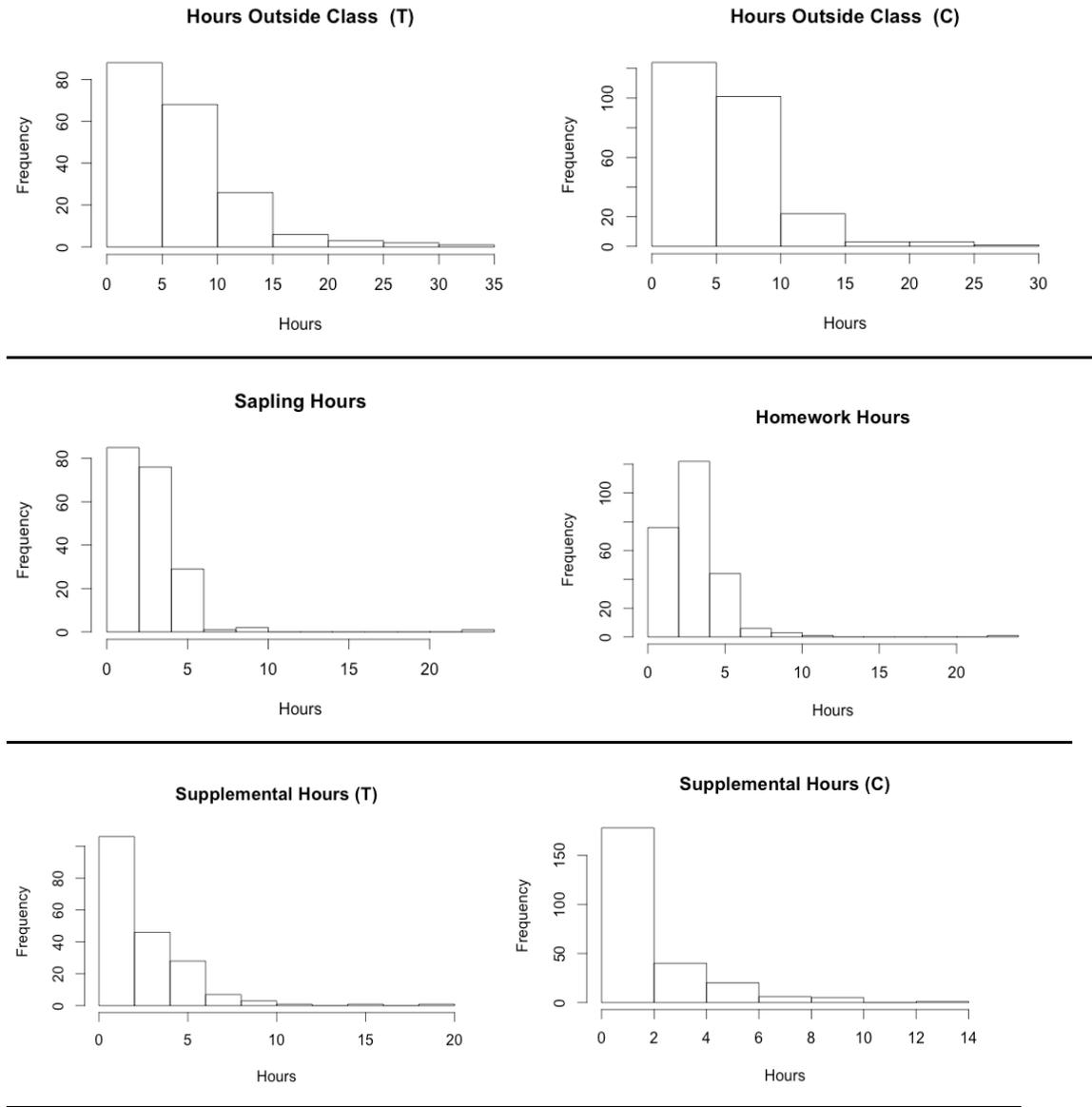


Students were asked to estimate the amount of time they spent working on Chem 51A coursework outside of class time. While the actual numbers are self-reported and thus likely to be inaccurate in terms of absolute values, comparisons between the two should give a general estimate of any significant differences in time on task (Figure 4). Median values were used instead of mean values due to the presence of a small number of outliers who self-reported spending more than 20-35 hours per week for coursework, homework assignments, and supplemental problems. Both groups reported spending a median value of 6.00 hours on coursework outside of class time indicating that requiring online homework did not cause any significant increase in workload. Students who completed Sapling Learning homework spent equal amounts of time on assigned homework problems as the student who completed assigned textbook homework with both groups reporting a median value of 3.00 hours spent on their respective homework assignments. Additionally, both groups reported spending a median value of 2.00 hours per week on supplemental homework or practice problems.

The equivalent self-reported values of time spent on class activities allow additional conclusions about the effect of Sapling Learning assignments on student performance. Often in education studies it can be difficult to differentiate between improvements based on the intervention itself versus improvements due to increased time on task. Because neither group has an incentive to inflate their time estimates more than the other, we can assume that similar inflations are likely in both cases. With both treatment and control groups reporting equal amounts of time spent on homework and coursework overall, the interaction effect identified in the statistical analysis cannot result from a simple increase of time on task for the treatment group.

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Figure 4. Self-reported Time Spent on Coursework



Survey Comments

A small subset of 36% percent of respondents from each group left additional comments in their survey responses. The comments were coded by general topic and are summarized in Table 3. A few representative comments are shown in Table 4. In general, the treatment group made mostly positive comments about the Sapling Learning homework while the control group commented on the helpfulness in their assigned textbook homework. A small number of students in each group would have preferred being assigned the opposite type of homework. Only six students in the treatment group made specific comments regarding any technical issues with Sapling Learning and an equal number of students in the control group made comments regarding technical issues with Sapling Learning when it was used in previous classes. A few students in each group made

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comments specifically related to grading concerns. These included wanting more credit for assigned homework, wanting less credit for assigned homework, and feeling stressed about losing points for incorrect attempts on Sapling Learning homework. Three students in the treatment group suggested improving the utility of the Sapling Learning homework by making the assignments available again as additional practice after the due date. Five students in the control group specifically mentioned the temptation, either for self or peers, to copy assigned textbook homework from the solutions manual for credit.

Table 3. Survey Comments Coded by Type

Treatment Group (73 comments)		Control Group (95 comments)	
<i>Positive comments about Sapling</i>	37	<i>Homework was helpful</i>	55
<i>Preferred textbook homework</i>	12	<i>Wanted Sapling</i>	14
<i>Wants both types</i>	17	<i>Wants both types</i>	8
<i>Neutral comments about Sapling</i>	1	<i>Copying solutions</i>	5
<i>Wanted to re-do Sapling problems</i>	3	<i>Writing solutions beneficial</i>	3
<i>Technical issues with Sapling</i>	6	<i>Previous technical issues with Sapling</i>	6
<i>Grading concerns</i>	2	<i>Grading concerns</i>	4

Table 4. Select Representative Comments

Treatment Group
<i>I think that sapling was a good alternate source that helped get more exposure to questions and other problems</i>
<i>The only complaint I have against sapling is that there is always an exact answer that you have to enter to get it right. If I am using the book, I can always explain my procedures or the answer, but on sapling, you have to be exact. Sapling is a great resource, nonetheless.</i>
<i>Sapling provides you with hints while the textbook does not. Sapling tells you if your wrong with a hint while the textbook does not. If you check the answer to a question you did in the textbook and look at the answer and got it wrong, the only thing you get out is the answer and why that is the answer.</i>
<i>I like sapling in that it is online, but it can be difficult to deal with when I know that if I do not get it correct the first time my grade will go down for that course category.</i>
Control Group
<i>I really liked having homework from the textbook. I found that the textbook explanations were very clear and that the questions were very similar to those on the test. I definitely preferred book homework to online homework!</i>
<i>It would have been better if the homework counted towards a larger percent. I feel that some did not complete it because it is just 3% of our grade. And doing the homework is extremely helpful.</i>
<i>The solutions manual was very helpful in correcting my mistakes and learning from them but I know many students who just copied their homework this way and did not get much out of it.</i>

Survey respondents' comments elucidate best practice suggestions for implementing Sapling Learning or other electronic homework in organic chemistry courses. Students in each group identified potential benefits to the opposite type of homework that they were given, and many students who completed Sapling homework indicated that they also completed textbook problems. An ideal course structure might include assigned and collected homework assignments from both Sapling Learning problems and textbook problems, however this might not be possible from a practical standpoint. Instead, it might be helpful to require a set of Sapling Learning problems and strongly emphasize to students that these problems constitute the bare minimum needed for a likelihood of only just passing the class while additional problems in Sapling and the textbook are suggested to achieve a higher grade. Duplicate versions of Sapling learning assignments should be made available after due dates for additional practice. To prevent frustration caused by technical difficulties, clear computer and Internet speed requirements should be stated and students should be required to complete training modules already provided within Sapling Learning. Finally, a simple problem in which students are asked to calculate the effect of answering a homework question incorrectly on their overall course grade could help to alleviate homework grade stress.

Summary

Students who completed Sapling Learning homework assignments showed increased final exam performance as compared to their peers in the control group with the lowest performing students exhibiting the most dramatic gains. The interaction effect diminished with increasing cumulative GPA and disappeared for students with GPA scores of 3.0 and above. Comparisons of midterm exam scores revealed a similar interaction effect for all students including those in the higher GPA group, but because the two groups were given different exam versions further analysis is needed. Student survey responses indicate generally positive feelings toward both types of homework and reveal suggestions for best practices in future courses. Additionally, equal self-reported estimates of time spent on homework negate the argument that the treatment group exhibited increased exam performance due to an increase of time on task.

Future Directions

The strongly positive effects of required online homework in the Sapling Learning system will be shared with other faculty to inform future decisions on course structure. A full analysis of the midterm exams will be conducted to verify the increased exam performance identified preliminarily among students with average GPA scores. Additionally, we are considering an in-depth look at student performance on individual exam questions to attempt to elucidate which learning objectives are best served by the existing online homework questions.