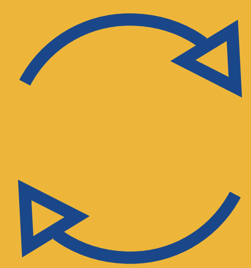
# Complete **TEXTBOOK READINGS** as part of a pre-lecture routine

**BETTER** understanding of material



**BETTER** academic performance

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## Completing textbook readings pre-lecture

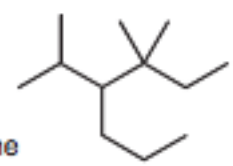
Collard, D. M., Girardot, S. P., & Deutsch, H. M. (2002). From the textbook to the lecture: improving prelecture preparation in organic chemistry. Journal of Chemical Education, 79(4), 520-523.

<u>Study Design</u>

- 180 undergraduate students partaking in an introductory organic chemistry course
- HWeb assignments were a part of the syllabus, provided with every lecture, and were composed of three multiple choice questions regarding any assigned readings
    - HWeb assignments were conducted online and available through the course website
    - Students would answer the assignments after the relevant lecture and before the next lecture where the correct answers would be discussed
    - Students were able to collaborate with fellow students and had unlimited time to answer questions with only one answer submission allowed
- At the end of the course students filled out a survey on attitudes towards the HWeb assignments, and wrote a standardized exam in order to compare their results with previous years

**HWeb6**

*Question 1.* What is the correct IUPAC name of the following compound?



1. 2,4,4-trimethyl-3-propylhexane
2. 4-propyl-3,3,5-trimethylhexane
3. 4-isopropyl-3,3-dimethylheptane
4. 2-ethyl-2,4-dimethyl-3-propylpentane

*Question 2.* How many of the constitutional isomers of $C_7H_{16}$ have no 3° hydrogens?

1. one
2. two
3. three
4. four

*Question 3.* Which of the following has the highest boiling point?

1. heptane
2. 2-methylheptane
3. octane
4. butane

**Example HWeb assignment**

Key Results

- Students who made the effort to complete the HWeb assignments, and subsequently the necessary textbook readings, had better grades in all other aspects of the course (homework, midterms, final exam) as well as higher **final** grades in comparison to students who did not complete/attempt a majority of the HWeb assignments

# From the Textbook to the Lecture: Improving Prelecture Preparation in Organic Chemistry

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Introductory chemistry courses taught in the first two years of the college curriculum, such as general and organic chemistry, typically have large enrollments and are for the most part populated by nonmajors. Because of the demands of these classes, the large-lecture format remains the primary method of instruction, even at medium-sized institutions. Within this format, many instructors still elect to employ a "chalk and talk" lecture delivery. Various studies suggest that students retain only a small percentage of the material covered in lecture (*1*), attendance at lectures does not improve performance (*2*), and the impersonal nature of lectures turns many students away from pursuing majors in science (*3*). In addition, the large-lecture format does not lend itself well to student–student or student–instructor interactions (*4*), and there is generally little emphasis on high-order thinking skills such as problem-solving analysis and knowledge integration (*5*). Finally, the depersonalized and assembly-line feeling of large lectures can be intimidating and frustrating to students who come from smaller high schools (*6*).

But given the reliance on the lecture method and the reluctance of many instructors and administrators to abandon it, the question becomes: What can we do to improve the learning experience within this system of instruction? A number of new teaching pedagogies have been developed to make time spent in lecture more meaningful and productive. These emphasize use of better presentation techniques (*7, 8*), prelecture assignments (*9*), collaborative-learning methods (*1, 4, 10*); in-class feedback devices (*11, 12*), active-learning methods (*13, 14*), and learning cycles (*15*).

However, to make these pedagogies truly effective we must consider how to improve student preparation. It is well recognized that if students attempt to master material on their own, they become more active learners during class time and are more successful at understanding the material (*9*). When students enter the classroom with a baseline amount of knowledge, they can truly be engaged with the material. This allows lectures to be used to illustrate concepts and approaches to problem solving and to enhance comprehension, instead of solely for information transfer, even if they are delivered in a traditional format.

Student preparation for lectures should involve, at a minimum, reading the appropriate material in the textbook ahead of time. In our experience, it is difficult to encourage the completion of this task. Moreover, research indicates that students have difficulty learning and retaining material from textbooks (*16–18*). Our approach to this problem has been to provide students with structured motivation to prepare for lectures by introducing online prelecture assignments. The assignments, which we have named "HWebs", are based on material to be covered in the *next* lecture and are given before *every* class period throughout a yearlong lecture series in introductory organic chemistry. This has been done without making drastic changes to the traditional lecture delivery and without taking time away from the lecture presentation itself. Yet over time it has allowed us to spend more time in class dealing with problem solving techniques and illustrations.

The approach was developed, in part, to address our perception that students do not use the textbook effectively and that lower-achieving students would benefit greatly from a structured approach to reading the textbook. In this paper, we describe this strategy and provide an assessment of how students responded to the assignments.

## The Course

The two-semester introductory organic chemistry lecture sequence at Georgia Tech has sections of 120–140 students (the laboratory course is separate). HWebs have been a feature of this course for two years, and students taking these courses during this period comprise the sample in this study. The required textbook for all students in this group was Solomons and Fryhle's *Organic Chemistry*, a popular and well-established text now in its seventh edition (*19*).

Lectures were delivered by projecting and writing over "skeleton" notes, which students downloaded from the course Web site prior to the lecture. These were not a complete set of notes, but rather incomplete templates that students could add to during the lecture. For example, while titles and text were complete, mechanisms would be missing electrons and curved arrows (*7*), and products would not be shown in reaction schemes. In this way, students could spend more time engaged with the material and delivery and less time copying notes. This approach also helps to avoid errors in transcription of information while still requiring students to attend lectures to get a complete set of notes.

Grades for the two courses were determined by performance on five midterm exams (100 points each), a comprehensive final (100 points), 10 homework assignments, and 35 HWeb assignments. The combined HWeb and homework grade (50 points each) could be used to replace the student's lowest grade on the midterm exams. This provided motivation for students to complete the HWebs, but still gave them the option to ignore the assignment.

## The HWeb Assignments

The syllabus given to students at the beginning of each semester listed a relevant reading assignment from the textbook and an HWeb assignment for every lecture. Each HWeb consisted of three multiple-choice questions related to the reading assignment. These questions ranged in difficulty from simple recognition problems that could be solved by identifying the concept in the assigned section of the book to more advanced synthesis problems that required in-depth and cumulative knowledge of the material. An example of an HWeb is shown in Figure 1. It should be noted that although these questions are simple once a student has experience with the concepts involved, the students have *no knowledge of these concepts prior to the HWeb assignment*. All students in a class had the same HWebs, although we changed the questions from one year to the next.

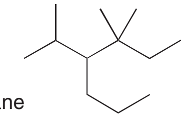
The assignments were made available to the students through the course Web site. WebCT, a World Wide Web–based course delivery and management system, enabled the assignments to be completed, submitted, and graded online (*20*). The HWebs can be answered from any computer with access to the World Wide Web. For each HWeb, students were required to do the following.

1. Log on to WebCT via the course Web site to select the appropriate HWeb assignment for the next lecture. Students could also download a compilation of questions in advance.
2. Answer the questions using any available resources, with the expectation that the assigned reading in the textbook provided all new information required to complete the assignments. Collaboration with fellow students was allowed.
3. Submit their answers using WebCT in the period between the last lecture and the start of the next lecture. Students were allowed unlimited time to answer the questions, but could submit answers only once. The correct answers were not made available until the lecture.
4. Record their submitted answers on a printed "HWeb Record Sheet". This allowed students to keep track of the answers they submitted online, record the correct answer when it was discussed in class, and keep track of their success.
5. Attend the lecture to discuss the questions and find out the correct answers, which were not available elsewhere. The instructors could evaluate student performance prior to the lecture by grading the assignments online and confirm this during the lecture by a show-of-hands survey of how students answered the questions. This allowed us to adjust the level of discussion in response to the success of students in answering each question.

**HWeb6**

*Question 1.* What is the correct IUPAC name of the following compound?

1. 2,4,4-trimethyl-3-propylhexane
2. 4-propyl-3,3,5-trimethylhexane
3. 4-isopropyl-3,3-dimethylheptane
4. 2-ethyl-2,4-dimethyl-3-propylpentane



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4. butane

Figure 1. A typical HWeb assignment.

## Assessment Methods

At the end of the second semester, an in-class survey was administered in the absence of the instructors to determine students' attitudes towards the HWeb concept. Giving the students class time to complete the survey resulted in a relatively high response rate (69%). The survey contained 5-item Likert-scale multiple-choice questions, to gauge students' attitudes (*21*), and free-response questions. The surveys were "unblinded" to correlate student performance with attitude after final grades had been submitted. A standardized ACS exam (Organic 1994) was administered as the final exam for the second-semester course to provide a comparison of student performance with the performance of students in previous organic courses who did not use HWebs.[W]

## How Students Approached the HWebs

We sought to determine *how* students used the textbook to complete the HWebs. A majority (56%) responded that they completed "all" or "most" of the HWebs by reading the textbook assignment to specifically look for the answers to the questions. A third of the students read the textbook before they even looked at the questions to complete "all" or "most" of the assignments. A few (10%) indicated that they copied or guessed answers. Overall, it was evident that students used the textbook to complete the assignments. A high percentage (61%) typically worked on the assignments alone rather than in groups (32%). While we encouraged collaboration on HWebs and homework assignments, we suspect that group work was not always feasible because of the students' demanding schedules and the frequency of the assignments.

## Students' Increased Use and Appreciation of the Textbook

The central idea behind the HWeb methodology was that if students were given motivation to prepare for lecture by reading the textbook, they would understand the lectures better and their performance in the course would improve. Furthermore, we hoped that by interacting with the textbook more frequently, students would better appreciate the role of it in their learning and understanding of the material. Our first objectives were to determine if we were successful in getting students to read the textbook before coming to lecture and in improving their attitude toward its role in the course.

It was evident that the HWeb assignments improved students' use of the textbook in the course. Approximately 74% students who responded to the survey indicated that they read the textbook before coming to class "very often" or "some-

**Table 1. HWeb Performance in Relation to Second-Semester Overall Course Grade**

| Course Letter Grade | Students (No.) | Av Course Grade[a] | HWebs Attempted (Av %)[b] | Success (Av %)[c] | Av HWeb Grade[d] |
|---|---|---|---|---|---|
| A | 39 | 89 | 95 | 84 | 79 |
| B | 74 | 75 | 91 | 77 | 69 |
| C | 46 | 65 | 85 | 70 | 60 |
| D | 15 | 55 | 73 | 59 | 43 |
| F | 6 | 40 | 63 | 60 | 38 |
| All students | 180 | 72 | 88 | 74 | 66 |

[a]Based on a maximum grade of 100.
[b]Based on a total of 35 HWebs for the second semester.
[c]Percentage of HWebs attempted that were answered correctly.
[d]Percentage of points earned out of 50 possible points.

what often", whereas only 26% responded similarly at the beginning of the course when asked about textbook usage in other college classes. We found that 78% of the students "agreed" or "strongly agreed" that they read the textbook before coming to lecture more often than in other lecture courses. Students overwhelmingly (88%) reported that the reason for this was because of the HWeb assignments. Finally, students responded positively when asked if the increased use of the textbook facilitated their understanding of the material. On a 5-point Likert scale, 5 being very positive attitude and 1 being very negative, the mean attitude response was a 4.4.

We further analyzed these attitudes on the basis of how students performed in the class. Overall, the data show that there was very little correlation between students' attitudes toward the textbook and their performance in the course. Two exceptions are apparent. First, higher-achieving students (A, B, and C) agreed more strongly that they read the textbook more in this class than in others: 4.2 on the Likert scale compared to 3.7 for D students. This might be explained by fact that D students are not motivated to read the textbook or prepare for class in *any* course, much less organic chemistry. Thus, their performance here is consistent with their performance in other courses. (We also note the small sample of D students responding to the survey, indicative of poor lecture attendance.) The second grade-dependant response is seen in the attitude toward the textbook's facilitation of understanding the material. This was higher for A students than for others: 4.6 compared to 4.3 for B and C students. Thus it appears that A students are better equipped for self-study and that they have a more positive attitude toward the textbook's role in the course and on their learning.

Although students made a strong connection between reading the textbook and improved understanding of the material and performance, they did *not* appreciate a direct connection between doing the HWebs and improved performance. In questions dispersed throughout the survey we asked students if the HWebs helped them to understand the lectures, improve their performance on exams, and improve their overall understanding of the material. Student attitudes toward these statements were relatively neutral, in contrast to their favorable opinion of the textbook. As for textbook usage, the attitudinal scores were similar for A, B, and C students and substantially lower for D students. The lower attitudinal scores of the D students also correlate with their lower response rate (percentage of HWebs attempted) and their success on these assignments (see later).

Qualitative data show HWebs were successful in getting students to "open the book and read". Comments such as "They help me keep up with the reading" and "They encourage me to read the chapter before going to the lecture" were repeated frequently in student responses. One student elaborated:

> They force me to do organic before coming to class. They begin to teach. The professor reinforces [the material] during lecture. I have friends in other organic classes who wish they had HWebs.

The notion that students appreciated being "forced" to do something they already knew that they should be doing was apparent in many of the responses. Student comments indicated a positive attitude toward the effect of HWebs on comprehension and understanding. For example:

> They help me to follow the lecture instead of blindly copying notes like in other classes.
>
> They make me do the reading…and that makes a difference in my understanding.

## Student Achievement

Using data obtained from the second-semester course, we found strong correlations between how students performed on the HWebs and how they performed in other aspects of the course. In relation to student grades, we analyzed the percentage of HWeb assignments attempted, the average HWeb grade earned (based on a maximum of 50 possible points), and success in answering the attempted questions correctly (Table 1). It is clear that the higher-achieving students attempted more HWebs. Furthermore, students who did better on the HWebs also scored higher on the other assignments (homework, exams, standardized final).[W] Students who made an A in the course, on average, attempted 95% of the HWeb assignments with 84% success to earn an average of 79% of the 50 possible points. Most students who did not complete a large majority of the HWeb assignments did poorly in all aspects of the course. Lower-achieving students, those who earned a D or F in the course, completed the smallest percentage of HWebs (73% and 69%, respectively) and had the lowest success rates (59% and 60%, respectively). Except for those receiving an A for the course, the success rate for all students was higher than their overall course grade. Thus, students who made the effort to complete the HWebs were rewarded with higher grades. This correlates with our belief that the use of HWebs would provide B and C students with support for their learning, that A students will succeed largely independent of the mode of instruction, and that D students remain difficult to motivate. We note that we gave fewer C's in classes completing HWebs than in previous classes without HWebs.

## Criticisms and Suggestions

Most students expressed an appreciation of the benefits of the HWebs, both in terms of the handful of points that were available and for the long-term effect on their learning. The most common criticism was that students were "penalized" for not understanding material that had not been "taught".

Our response, of course, is that teaching and learning now begin *before* the lecture and that the textbook is an excellent educational resource. Other students felt that their grades were hurt if they fell behind with the reading assignments. While this is undoubtedly true, the HWebs motivated many students to keep up to date. We believe that the benefit of completing the HWebs is not limited to the few points available for successfully answering the questions, but that a majority of the benefit accrues from continuous reading and learning. Indeed, perhaps the greatest benefit is realized when students incorrectly answer an HWeb question and reassess their understanding of a concept during discussion of the HWebs in the lecture. The loss of a point on the HWebs is more than compensated for if students learn from their mistakes and successfully answer questions on these concepts on the examinations.

Other criticisms were that HWebs do not count enough toward the course grade to merit the time required to do them, and that having an assignment due before *every* lecture is too demanding. We counter with the fact that HWebs are optional and generally raise the students' scores, and that learning really is a continuous process, with new information introduced in each lecture.

It was clear that most students appreciated the long-term benefits of the HWebs on their learning. One effect was an increased understanding of the lectures. Approximately 66% of students strongly agreed or agreed with the statement that completing the HWebs "helps me to understand the lectures"; only 13% disagreed or strongly disagreed with this statement. Another long-term effect was the increased practice with multiple-choice questions. Students did better on the all multiple-choice final than in previous years, perhaps in part because of the practice they had with the HWeb questions. Finally, it should be noted that the HWebs actually *improved* the grades of 85% of the students by allowing them to "drop" a midterm exam grade. The B, C, and D students benefited most from this policy; 90% of them replaced a low midterm exam score. Two A students ignored the HWeb assignments entirely, clearly not needing the motivation or structure to achieve a high level of success.

Despite these criticisms, students attempted, on average, 88% of the HWebs (i.e., >30 of 35 assignments). Students clearly felt that they should complete the assignments, they understood the benefits, and they were rewarded.

## Conclusions

The use of HWebs in our introductory organic lecture sequence was a simple and efficient way to improve student preparation for lectures. The assignments gave students a structured format to begin learning material before they came to class. In addition, they improved students' use the textbook. This led to an increased understanding of the material and an improvement in student performance. Although students did not recognize a direct connection between the HWebs and improved comprehension, we believe that these are strongly related: the prelecture assignments clearly provided encouragement to read the book, which was recognized as a useful learning resource.

For faculty who are hesitant to make substantial changes to the traditional lecture format, HWebs might provide an excellent alternative. They can be incorporated into the course without taking away precious lecture time. They make it possible to devote less lecture time to information transfer and more to higher-order learning.

## Acknowledgments

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## W Supplemental Material

The survey, with some selected results and further data analysis, is available in this issue of *JCE Online*.

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