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TextRev: A Window into How General and Organic Chemistry Students Use Textbook Resources

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Although textbooks and their ancillary resources, such as study guides, solution manuals, CD-ROMs, Web sites, et cetera, are commonplace in most lower-division chemistry courses, there are very few studies reporting how students use and value these products *(1).* Currently available review resources include the book review sections of this *Journal* and the Internet sites *http://www.amazon.com* (accessed Sept 2002) and *http://www.facultyonline.com* (accessed Sept 2002). Unfortunately, these represent the opinions of a small number of instructors rather than a statistically significant sample of student and faculty users. The chemical education literature contains articles on the scientific misconceptions found in textbooks *(2),* and suggestions for improvement *(3),* but very few examine how students use or react to different chemistry textbook features *(4).* Likewise, there are only a handful of articles assessing textbooks in related disciplines such as biology *(5),* medicine *(6),* and engineering *(7).*

Chemistry is a dense, content-filled subject, and the majority of instructors derive their course material directly from textbooks. Instructors with heavy teaching loads have little free time to generate their own examples from the primary literature. Thus, textbooks play a vital role in determining course curricula, both in terms of specific content and pedagogical approach.

The task of choosing a suitable textbook for a college class is not straightforward; it has been known for some time that most professors do not employ a systematic procedure when making the choice *(8).* The textbook market for lower-level college chemistry courses is quite mature with a large number of available titles (Table 1). The recent advent of Internet and multimedia presentation methods is making the utilization of textbook resources an increasingly complicated issue. At the same time, the textbook publishing industry is undergoing major worldwide consolidation, resulting in fewer textbook publishers with larger marketing divisions. Thus, in the future it may become even harder to gain objective information about the suitability of a textbook and its ancillaries.

Here we exploit TextRev, a new resource for collecting, analyzing, and disseminating survey data about textbook usage. The TextRev Web site, *http://www.textrev.com* (accessed Sept 2002), offers any instructor a free tool for conducting an Internet-delivered survey of his or her own students to learn how they utilize and benefit from the course materials. The specific focus of this article is to describe a paper-based survey conducted by TextRev in December, 2000 targeting first-year general chemistry and second-year organic chemistry students. Responses were collected from approximately 3200 students and 23 instructors at nine U.S. institutions. A total of ten textbooks were examined. Unless stated otherwise, the data reflect student opinions near the end of their first semester in the class. Students and instructors answered questions about the time they spent using various textbooks resources, and the quality and helpfulness of specific textbook features.

Results

Class Demographics

A summary of the student demographics is shown in Table 2. Most of the respondents were from large research universities, which is reflected by the average class size of slightly above 200. The average male/female ratio was close to 50/50 for first-year general chemistry but was approxi-

Table 1. Current Number of Available Chemistry Textbooks

Chemistry Course	Number
General (majors)	54
General (non-majors)	26
Organic	60
Analytical	24
Environmental	88
Inorganic	41
Physical	39
Biochemical	62

NOTE: Data from *J. Chem. Educ.*, Buyers Guide, Harris, H., Ed.; 2001.

Table 2. Student Demographics

Parameter	First-Year General Chemistry	Second-Year Organic Chemistry
Number of respondents	2084 (54% of class)	1137 (70% of class)
Class size (average)	214	204
Average age (years)	19.3	20.3
Male/Female ratio (average)	47/53	39/61
Anticipated GPA[a] (average)	3.11	2.82

[a]GPA calculated by assigning a score of : A = 4, B = 3, C = 2, and D = 1.

mately 40/60 for the second-year organic chemistry classes. The average anticipated grade point average (GPA) of 3.11 (calculated by assigning a score of A = 4, B = 3, C = 2, and D = 1) for general chemistry was noticeably higher than the 2.82 reported for organic chemistry. In a few cases we were able to compare the anticipated GPA for a class with the actual GPA; we found that students slightly overestimated their grades (first-year students overestimated by 0.45 and 0.25 in the fall and spring, respectively, and second-year students by 0.20) in agreement with the findings of other studies *(9).*

Hours Spent per Week Using Textbook Resources

General chemistry students reported spending an average of 4.1 ± 0.1 hours per week using the following textbook resources: textbook, study guide, solutions manual, textbook's Web site, and accompanying CD. By comparison, organic chemistry students reported spending an average of 5.8 ± 0.2 hours per week. For each of these two courses, Figure 1 shows the average number of hours students spent studying chemistry each week as a function of their anticipated letter grade. In the case of general chemistry, the data shows a statistically significant correlation between weekly hours and the student's anticipated letter grade. The C students reported spending more time per week studying chemistry than the B students, who in turn spent more time than the A students (ANOVA: $F = 10.9$, $p = 10^{-7}$; see Note 1). With regards to organic chemistry, the data do not suggest a significant correlation between the weekly hours and the student's anticipated letter grade (ANOVA: $F = 0.62$, $p = .60$).

The fractional distribution of weekly hours is shown in Figure 2. The general chemistry students spent, on average, 64 ± 3% of their time using the textbook and 29 ± 2% of their time using the study guide or solutions manual. The organic chemistry students spent a smaller fraction of their time using the textbook (58 ± 5%) and comparatively more time using the study guide or solutions manual (36 ± 2%). Both groups spent 7 ± 1% of their time using the textbook's Web site or the accompanying CD.

Helpfulness of Textbook Features

Student responses to the statement "Select the answer that best reflects how each of the following textbook features helps your learning" are listed in Table 3. These scores are the average student ratings on a scale of zero (least helpful) to ten (most helpful), with uncertainties corresponding to 95% confidence limits. For general chemistry, the features perceived to contribute most to student learning were in-chapter example problems (7.4 ± 0.1), end-of-chapter problems (7.1 ± 0.1), and written text (6.8 ± 0.1); whereas for organic chemistry, the highest-rated features were the solutions manual (7.4 ± 0.1), in-chapter example problems (7.3 ± 0.1), and end-of-chapter problems (7.3 ± 0.1). In both courses, the lowest-rated features were the animations or simulations (5.2 ± 0.1 and 4.8 ± 0.2, respectively), examples of real world application or situations (5.3 ± 0.1 and 4.5 ± 0.1), and the study guide (5.1 ± 0.1 and 5.0 ± 0.2). In a comparative sense, general chemistry students rated examples of real world application or situations significantly higher ($p = 10^{-12}$) than did organic chemistry students (5.3 ± 0.1 versus 4.5 ± 0.1), but rated solutions manual (6.4 ± 0.1 versus 7.4 ± 0.1) and images or photographs (6.4 ± 0.1 versus 7.1 ± 0.1) significantly lower ($p = 10^{-21}$ and 10^{-13}, respectively).

Semester Comparison: General Chemistry

Organic chemistry students reported spending, on average, 42 ± 3% more time using textbook resources than first-year general chemistry students reported. To learn when this transition in study commitment takes place, the students within a very large two-semester general chemistry class (~480 students) with one instructor and textbook, were issued the same survey at the end of the first and second semesters. The average anticipated GPA was 3.21 ± 0.09 at the end of the first semester and 3.06 ± 0.13 at the end of the second semester. Corresponding with this slight drop in grade expectation ($p = .084$), the self-reported hours per week using textbook resources did not change significantly (3.6 ± 0.3 to 3.4 ± 0.3 hours, $p = .69$). Average helpfulness ratings for various textbook features are listed in Table 3. The only feature whose rating went up significantly over the two-semester period was

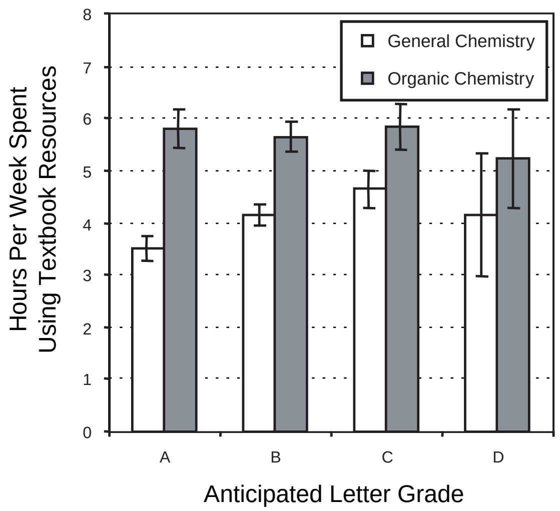

Figure 1. Self-reported hours per week spent using the following textbook resources: textbook, study guide, solutions manual, textbook's Web site, and accompanying CD. The data are sorted according to the student's anticipated grade in the course. Error bars correspond to 95% confidence limits.

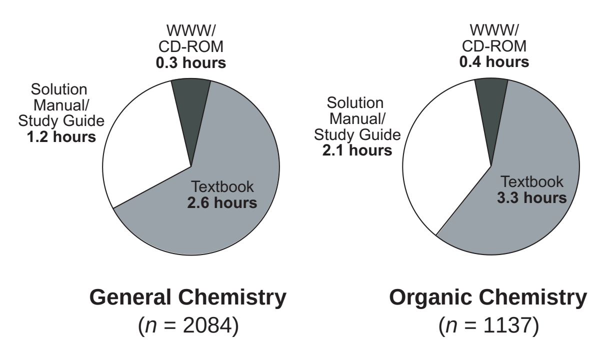

Figure 2. Self-reported hours per week spent using different textbook resources. Typically, the study guide and solutions manual are combined into a single book for organic chemistry. The uncertainty in the mean time spent with any given resource is less than 0.1 hours per week.

the in-chapter example problems, whereas the features with a significantly decreased rating were the images or photographs, examples of real world applications or situations, animations or simulations, and chapter summaries or glossaries.

Discussion

The order of average self-reported hours per week using textbook resources for first-year general chemistry students correlates with anticipated grades in the following way: C > B > A (Figure 1). It is possible that a higher fraction of the weaker students consciously inflated their hours, or included inefficient time in their estimate. However, evidence against these explanations is the data for the second-year organic chemistry students, which do not show this trend. It appears that study effort alone in first-year general chemistry does not guarantee a better grade. Students with an extensive high school chemistry background may not need to study as long to earn a grade of A, compared to less-prepared students who struggle to achieve a grade of B or C. This is not the case in second-year organic chemistry, where the material is new for a larger fraction of the class. The student time commitment increased and showed no strong correlation with anticipated grade.

Compared with general chemistry students, organic chemistry students reported spending more time using the solutions manual and rated it as significantly more helpful (Figure 2 and Table 3). This result suggests that organic students spend a greater fraction of their study time solving problems than do general chemistry students. General chemistry students appear to focus more of their effort on learning the chemistry concepts as presented in the textbook. In addition, general chemistry students rated examples of real world applications or situations as significantly more helpful than did organic students. Compared with general chemistry students, organic students rated images or photographs as more helpful, probably reflecting a stronger emphasis of course content on molecular geometry (stereochemistry).

The data in Table 3 suggest that over the course of two semesters the students in one selected general chemistry class increasingly valued those textbook features that they perceived would directly help them solve general chemistry problems. The helpfulness ratings for in-chapter example problems increased, whereas the ratings for animations or simulations, images or photographs and examples of real life applications or situations declined the most.

Students' commitment of time to using the textbook's Web site and accompanying CD was remarkably low across the entire surveyed population, even though these resources were, in most cases, recommended by most of the instructors. The plethora of available textbook resources means that students must prioritize their study schedule. They look to the instructor for indicators as to what "really matters," and they take their cues from the mechanisms the instructor has developed for awarding credit to students. If the exams or graded assignments do not ask students to recall or build on information revealed through animations, simulations, or other electronically delivered materials, then most students will choose not to commit time to working with these resources. To increase utilization of CD-ROMs and textbook

Table 3. Average Student Ratings of Textbook Features[a]

Textbook Feature	First-Year versus Second-Year Courses			General Chemistry Class over Two Semesters[b]		
	General Chemistry (n = 2084)	Organic Chemistry (n =1137)	p value (two-tailed probability)[c]	1st Semester (n = 250, 48% of class)	2nd Semester (n = 168, 36% of class)	p value (two-tailed probability)[c]
Written text	6.8 ± 0.1	7.0 ± 0.1	.110	7.2 ± 0.3	7.7 ± 0.3	.025
Images or photographs	6.4 ± 0.1	7.1 ± 0.1	10^{-13}	6.8 ± 0.3	5.9 ± 0.4	.001
Examples of real world applications or situations	5.3 ± 0.1	4.5 ± 0.1	10^{-12}	4.7 ± 0.3	3.6 ± 0.4	.001
In-chapter example problems	7.4 ± 0.1	7.3 ± 0.1	.76	7.0 ± 0.3	7.7 ± 0.4	.008
End-of-chapter problems	7.1 ± 0.1	7.3 ± 0.1	.010	7.4 ± 0.3	7.7 ± 0.4	.19
Chapter summaries or glossaries	6.1 ± 0.1	6.2 ± 0.1	.14	6.2 ± 0.3	5.5 ± 0.4	.011
Solutions manual	6.4 ± 0.1	7.4 ± 0.1	10^{-21}	6.1 ± 0.4	5.9 ± 0.5	.043
Study guide	5.1 ± 0.1	5.0 ± 0.2	.25	4.8 ± 0.4[d]	3.9 ± 0.5[d]	.023
Animations or simulations	5.2 ± 0.1	4.8 ± 0.2	.004	5.3 ± 0.4	4.1 ± 0.4	.001

[a]Response on a scale of 0–10. Uncertainties represent 95% confidence limits.

[b]Different samples were taken of a single student population across two semesters. Students had the same instructor and textbook each semester.

[c]Two-sample t-test assuming unequal variances. See Note 2.

[d]Study guide was suggested but not required.

Web sites, publishers must work to develop a more integrated package, where a portion of end-of-chapter problems, online quizzes, and test-bank questions draw explicitly from material presented electronically. This will give interested instructors a realistic strategy for effectively using the full range of resources or media that have been designed to enhance student learning.

Conclusion

In summary, TextRev's survey of more than 3200 first-year and second-year chemistry students provides a rare snapshot of how students used and valued current textbooks and their ancillaries. The data probably raise as many questions as produce answers; however, the survey results do help reveal the study habits adopted by a majority of students in lower-division chemistry classes.

Ongoing goals of the TextRev project are to improve the survey process and to gather data from a more diverse population representing the entire range of students and institutions in higher education. Instructors can visit *http://www.textrev.com* (accessed Sept 2002) and freely use the full range of resources available. The TextRev Web site administers a survey instrument that allows an instructor to easily customize, conduct, and interpret an anonymous survey of his or her own students. The instructor will then receive a confidential summary report showing a complete item analysis and percentile rankings for comparing class averages to a national database. In addition, the Web site posts summary listings of survey results representing anonymous student and instructor reviews of individual textbooks.

Notes

1. The purpose of analysis of variance (ANOVA) is to test for significant differences between means calculated from separate samples within a population. In the present case, the samples are defined by the students' anticipated letter grades in the course. The F-ratio is a measure of the mean variances within the samples, divided by the variance of the sample means. A large value of F is consistent with the sample means being significantly different from one another. The p value represents the probability that the difference recorded between group means occurs by random chance, that is, the likelihood that the null hypothesis is true. Ratings with p values below .01 are considered to be statistically significant.

2. The t-test computes the probability that the difference in two reported mean values, as calculated from separate samples of students completing the survey in the Fall and Spring semesters, could be due to natural variance. When the two-tailed probability, p, falls below .01, the null hypothesis is dismissed, and the difference in means is said to be statistically significant. The t-test gives the same result as ANOVA when the means from only two samples are compared.

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