

# Online Homework, Help or Hindrance? What Students Think and How They Perform

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*To improve students' retention rates in general chemistry, online homework was introduced into our curriculum. Replacing quizzes directly by online homework significantly improved ( $p < .0005$ ) success rates in second-term general chemistry. Attitudinal Likert survey results indicate that the majority of students completed the online homework assignments (90%) and viewed the assignments as worth the effort (83.5%). Students were overwhelming (85.7%) in their recommendation that online homework use should continue. More consistent study habits were reported by 75.6% of students, and students reported using a suite of effective problem-solving approaches for questions marked as incorrect. Our instructors have willingly embraced the use of online homework and point to the incredible amount of time savings for the instructor as reason enough to use online homework.*

Chickering and Gamson's seven principles for good practice in undergraduate education are as applicable today as they were in 1987. In fact, it is well documented that encouraging active learning (principle 3; Knight and Wood 2005; Handelsman, Miller, and Pfund 2007; Brooks and Crippen 2006; Farrell, Moog, and Spencer 1999; Oliver-Hoyo et al. 2004; Pooch et al. 2007; Varma-Nelson and Coppola 2004) and increasing student time-on-task (principle 5; Varma-Nelson and Coppola 2004; Cooper and Valentine 2001; Keith, Diamond-Hallam, and Fine 2004; Keith and DeGraff 1977) enhance learning. In the teaching of undergraduate chemistry, a variety of in-class (e.g., Process Oriented Guided Inquiry Learning [POGIL; Farrell, Moog, and Spencer 1999], Student-Centered Active Learning Environment for Undergraduate Pro-

grams [SCALE-UP; Oliver-Hoyo et al. 2004], Science Writing Heuristic [Pooch et al. 2007], and use of personal response systems [Handelsman, Miller, and Pfund 2007]) and out-of-class (e.g., Peer-Led Team Learning [PLTL; Varma-Nelson and Coppola 2004] and web-based practice and assessment systems [Penn, Nedeff, and Gozdzik 2000]) active learning instructional techniques have been used to improve learning. In addition, research in the field of educational psychology has indicated that time spent doing homework outside of class (time-on-task) is positively correlated with achievement. This correlation improves as students progress from elementary through middle and into high school (Cooper and Valentine 2001; Keith, Diamond-Hallam, and Fine 2004).

Beginning in fall 2005, decreased success in large enrollment introduc-

tory chemistry coursework at our postsecondary institution was attributed to increased enrollment. Total university and freshman enrollments had increased by 14% and 25%, respectively, from fall 2001 (22,774 students; 3,661 freshmen) to fall 2005 (26,051 students; 4,574 freshmen) and "extra" students were assumed to have come from the "weaker" end of the ability scale (Fletcher 1999). Increased enrollment of 7.6% in our preparatory chemistry course (a remedial course focused on problem solving) from fall 2001 (1,203 students) to fall 2005 (1,295 students) seemed to validate this assumption. However, enrollment alone did not explain the unacceptably low success rates in large enrollment introductory chemistry coursework.

A method of promoting active participation of undergraduate students in the learning process and increasing student time-on-task without significantly increasing instructor time-on-task was deemed necessary for improved student success in large enrollment introductory chemistry coursework. Commercially available online homework systems (e.g., MasteringChemistry, ARIS, WileyPLUS, WebAssign, OWL, ALEKS) were attractive for increasing student time on task because (1) most publishers were offering free trials and (2) online systems offer immediate feedback and assessment, which is known to

improve the learning process (Penn, Nedeff, and Gozdzik 2000; Epstein, Epstein, and Brosvic 2001; Henly and Reid 2001; Freasier, Collins, and Newitt 2003).

Two years ago, when our department began reviewing new textbooks for our introductory chemistry courses, we arranged for many of the large publishing companies to demonstrate the online homework systems that would accompany their texts. Foremost were questions such as: how intuitive and user friendly was the software interface for students and instructors, how randomizable/algorithmic were the questions, what tolerance was set for the answers, how were grades collected and answers viewed by the instructor, was higher-level thinking promoted by the questions, how were common misconceptions handled, and were connections to supplemental material (ebook, tutorials, etc.) provided for those students who needed more help. For our department, the choice of the online homework system drove the choice of the text; in other words, we chose the online homework system first, and then we chose a correlated text. This paper discusses our own department's switch from weekly quizzes to online homework in an attempt to increase student time-on-task without dramatically increasing the instructor's workload. Pertinent research questions addressed within are as follows:

1. Does online homework improve student performance in general chemistry coursework? In particular, (a) are grade components and online homework performance correlated, and (b) does online homework improve success rates in general chemistry?
2. Do students complete online

homework and do they recommend its continued use?

3. How is online homework perceived by students? Do they feel that online homework is helpful in (a) learning chemistry content, (b) improving their study habits, and (c) improving their exam scores and final grades?

### Background

Large enrollment introductory science courses are typically fraught with challenges such as varied educational backgrounds of the students, large amounts of content to be covered in a short amount of time, and difficulty keeping students engaged in the material. Clearly, not all of the learning in a course can, or should, take place during the lecture portion of the course. In courses such as chemistry, where there is a strong correlation with the students' time-on-task (e.g., homework) and their ultimate success in the course, opportunities for engagement in the material outside of class are paramount (Cuadros, Yaron, and Leinhardt 2007). Assigning homework has always been a common means by which teachers promote learning outside of the classroom. However, when class enrollment reaches beyond 90 students, the collection and grading of said homework becomes a new challenge in and of itself. Several common homework methods have been adopted by instructors of large enrollment classes, such as (1) assign but don't grade, (2) grade only a few randomized questions, or (3) have the assignment graded by a teaching assistant (Bonham, Beichner, and Deardorff 2001). More recently, the use of web-based practice and assessment systems (online homework systems) as a means of collecting and grading homework

has become popular. The pedagogical backgrounds of various web-based online homework systems, as well as implementation scenarios and relative merits of various online homework systems, have been reviewed extensively in the literature (Brooks and Crippen 2006; Harris 2009; Rowley 2009; Zhao 2009; Shepherd 2009; Evans 2009; Miller 2009; Hendrickson 2009).

Learning improvements attributed to the use of web-based online homework systems have been reported in a variety of fields including organic chemistry (Penn, Nedeff, and Gozdzik 2000), mathematics (Bressoud 2009), physics (Bonham, Beichner, and Deardorff 2001; Cheng et al. 2004), and general chemistry (Freasier, Collins, and Newitt 2003; Fynnewer 2008; Cole and Todd 2003; Arasasingham et al. 2005). In a study of introductory physics classes, Cheng et al. (2004) compared sections with graded online homework to sections with ungraded homework using the force concept inventory. A significant improvement in student understanding was found for the sections utilizing graded online homework. Bonham, Beichner, and Deardorff (2001) compared the grades of physics students completing online computer-graded homework to those of physics students completing traditional paper-based, hand-graded homework. In this study, two sections of physics were taught by the same instructor and were given the same homework assignments. However, students in the computer-graded section submitted their work through WebAssign with resubmissions permitted, whereas students in the hand-graded section submitted their work once on paper to a graduate teaching assistant. Although the computer-graded section self-reported spending more time-on-task

outside of lecture, the study found no statistical differences in exam scores or final grades between the two sections. The use of web-based online homework for general chemistry students was studied by Herb Fynewever (2008). Similar to the Bonham study, two sections of general chemistry, one with hand-graded paper homework and one with computer-graded online homework, were compared. Students in the hand-graded homework section were given one chance to submit and had a two-day delay in their feedback, whereas students in the computer-graded online homework section had the option to resubmit and received instant feedback on correctness. Again, no significant grade differences were found between students in the two sections; however, student surveys from both groups indicated that students recognized the benefit of homework. Furthermore, the instructor acknowledged a sizeable time-saving advantage in using the online homework system, both in terms of grading and collection and distribution of homework. In a study by Freasier, Collins, and Newitt (2003), it was found that students voluntarily completed online quizzes beyond those required, and 94% of students agreed that online quizzes were helpful. Although it is debatable whether online computer-graded homework offers an improvement in student learning over hand-graded, paper-based homework (Cole and Todd 2003; Arasasingham et al. 2005; Charlesworth and Vician 2003), the use of graded homework has shown a positive impact in all subjects and at all grade levels (Fynewever 2008; Cooper et al. 2006). Online homework has an added benefit: significant time and labor savings for instructors in terms of reduced amounts of hand grading, decreased student traffic

during office hours, and limited necessity for outside review sessions or recitations (Penn, Nedef, and Gozdzik 2000; Bressoud 2009; Fynewever 2008; Cole and Todd 2003; Dori and Barak 2003). With the added benefit of predeveloped systems that accompany most introductory chemistry texts and substantial time savings on the part of the instructor, online homework systems offer a clear advantage to increasing student's time-on-task outside of the lecture hall.

But what are students' perceptions toward online homework? Do they recognize the benefits, and does its use influence their study habits? Several researchers have reported that students are generally positive toward online homework use (Freasier, Collins, and Newitt 2003; Arasasingham et al. 2005; Charlesworth and Vician 2003), but there has been little in-depth analysis of student perceptions. In addition, what about instructors not invested in the chemical education community? Do they perceive the benefits of online homework use? The results discussed herein attempt to address these issues head-on.

### Research methodology

The WileyPLUS system was used for administration of online homework from fall 2006 to fall 2008 because it was offered along with the chemistry text by Brady and Senese (2004) used at that time. Beginning in spring 2009, online homework was delivered using the MasteringChemistry platform. Prior to the implementation of online homework, weekly in-laboratory quizzes were used for formative assessment of content knowledge in second-term general chemistry. The quiz average (calculated after dropping the lowest of nine quiz scores) counted 10% toward each student's final numerical grade. Performance

on these quizzes was poor, and semester quiz averages for off-semester second-term general chemistry classes taught by Instructor A ranged from 59% to 67% (fall 2002–2005). To improve students' content knowledge, time-on-task, and retention rates in off-semester second-term general chemistry, mandatory graded online homework was implemented in the fall of 2006. During that semester, Instructor A replaced weekly quizzes with a minimum of 18 mandatory graded online homework assignments in both of her off-semester second-term general chemistry classes. Each online homework assignment contained an average of 19–20 questions with different formats (multiple choice, text entry, numeric entry, algorithmic, true/false, etc.). Students were given three attempts to correctly answer each question, and online homework assignments were due 3–7 days after posting. Each student's final online homework average was worth 10% of the final numeric grade, with the online homework average directly replacing the quiz average.

### Survey and data collection method

Data on success rates in second-term general chemistry courses and freshman and main campus enrollment figures were obtained by accessing the institutional Information for Decision Enabling and Analysis System (IDEAS). For the purposes of this study, success rates were defined as the number of students earning grades of A, B, or C relative to the total number of students enrolled in the course. Instructor records for specific courses provided the information needed for correlating quiz and online homework averages with exam averages, final exam score, and final numerical grade.

The attitudinal online homework survey instrument, entitled “Chem 116 Online Homework Evaluation,” consisted of 36 Likert-type statements, 4 demographic questions, and 4 free-response questions. Likert-type statements covered topics of online homework completion, understanding, attitudes, study habits, perceived affect on grades, as well as other questions of interest to the investigators. A 5-point Likert scale (a = *strongly agree*, b = *agree*, c = *neutral* (or neither agree nor disagree), d = *disagree*, and e = *strongly disagree*) was used to assess the extent of agreement with each of the 36 statements. Free-response questions were structured so that students could provide detailed comments on their use of online homework and to aid in triangulation of the data. This research was reviewed and granted exemption by the Institutional Review Board at our institution.

This survey was administered during the last week of lecture to stu-

dents in four different sections of off-semester second-term general chemistry, two sections during fall 2006 and two during fall 2007. All four sections were taught by Instructor A. To maximize the quality of student feedback, surveys were administered during the first 15 minutes of lecture. Only students who attended lecture the day the surveys were administered had the opportunity to complete the survey. However, survey responses were obtained from 180 of 226 students (80%) and 153 of 217 students (71%) students during fall 2006 and fall 2007, respectively. Student participation in the survey was voluntary and anonymous.

### Results and discussion Quizzes versus online homework

For all off-semester second-term general chemistry courses taught by Instructor A from fall 2002 to fall 2005, correlations between quiz av-

erages and grade components (exam averages, final exam scores, etc.) are shown in Table 1. Correlations between quiz average and grade components range in value from 0.68 to 0.87 and are strongly positive, indicating that quiz performance was a good predictor of success in second-term general chemistry.

Beginning in fall 2006, online homework replaced quizzes in off-semester second-term general chemistry. Thus, correlations between online homework averages and grade components for off-semester second-term general chemistry courses taught by Instructor A are shown in Table 2. These correlations are mildly positive, ranging in value from 0.39 to 0.74.

### Success rates: Before and after implementation

Beginning in spring 2007, all instructors responsible for teaching second-term general chemistry used online homework in place of quizzes. As

TABLE 1

**Correlations between quiz average and exam average, final exam score, final numerical grade, and final numerical grade less quiz contribution for off-semester second-term general chemistry classes taught by Instructor A from fall 2002 to fall 2005 (semester quiz averages are shown in the last column).**

Semester, year, and section number	Correlation: Quiz average vs. exam average	Correlation: Quiz average vs. final exam	Correlation: Quiz average vs. final numerical grade	Correlation: Quiz average vs. final numerical grade less quiz contribution	Quiz average
Fall 2005 Chem 116-001	0.79	0.73	0.87	0.83	67.1% (N = 145)
Fall 2005 Chem 116-003	0.79	0.78	0.88	0.84	62.7% (N = 84)
Fall 2004 Chem 116-001	0.72	0.68	0.82	0.76	66.2% (N = 157)
Fall 2003 Chem 116-001	0.79	0.71	0.85	0.81	65.6% (N = 157)
Fall 2002 Chem 116-001	0.81	0.76	0.87	0.83	59.1% (N = 163)
All sections of Chem 116 listed above (fall 2002 to fall 2005)	0.78	0.72	0.85	0.81	64.2% (N = 706)

shown in Table 3, the percentage of students earning grades of A, B, or C (success rate) in second-term general chemistry in both fall (off-) and spring (on-) semesters improved after the implementation of online homework. The average rate of success after implementation improved by 3.7%, 9.9%, and 7.9%, respectively, for fall (off-) semester, spring (on-) semester, and both spring and fall semesters combined. Although different instructors taught these courses over the time period in question (fall 2001 to spring 2009), the course itself was administered by Instructor A and course syllabi, grading schemes, and grading scales were (1) coordinated across sections and (2) unchanged throughout the time period in question. For fall (off-) semester second-term general chemistry classes,

Instructor A taught 7 of 10 sections prior to and 6 of 6 sections after implementation of online homework. For spring (on-) semester second-term general chemistry classes, different instructors taught the various sections. To better evaluate the significance of these improvements, comparative statistics for evaluating inferences about proportions were used to calculate large-sample confidence intervals. For fall and spring semesters combined, we are 99.9% confident ( $p < .0005$ ) that use of online homework (relative to quizzes and ungraded homework) improves student success in second-term general chemistry by between 3.8% and 12.1%. In addition, success rates in second-term general chemistry have improved since the implementation of online homework, despite ever-

increasing enrollments, that is, total university and freshman enrollments have increased by 10.7% and 12.3%, respectively, from 2005 to 2008.

### Online homework survey results

It is important to keep in mind that survey data are self-reported by each student in a particular section of off-semester second-term general chemistry. However, given the nature of the dissemination and the high rate of return, it is believed that a representative sample of student responses has been obtained. The self-reporting nature of the data may provide additional insights into students' attitudes toward online homework, study habits, and perceived grades in general. Survey results from fall 2006 ( $N = 180$ ) and fall 2007 ( $N = 153$ ) have been combined to obtain

**TABLE 2**

**Correlations between online homework average and exam average, final exam score, final numerical grade, and final numerical grade less online homework contribution for off-semester second-term general chemistry classes taught by Instructor A from fall 2006 to fall 2008 (semester online homework averages are given in the last column for comparison).**

Semester, year, and section number	Correlation: Online homework average vs. exam average	Correlation: Online homework average vs. final exam	Correlation: Online homework average vs. final numerical grade	Correlation: Online homework average vs. numerical grade less online homework contribution	Online homework average
Fall 2008 Chem 116-001	0.62	0.50	0.71	0.59	75.0% ( $N = 152$ )
Fall 2008 Chem 116-003	0.63	0.57	0.73	0.65	73.7% ( $N = 69$ )
Fall 2007 Chem 116-001	0.57	0.51	0.61	0.53	77.9% ( $N = 157$ )
Fall 2007 Chem 116-003	0.66	0.60	0.74	0.66	70.1% ( $N = 72$ )
Fall 2006 Chem 116-001	0.39	0.44	0.57	0.47	83.8% ( $N = 156$ )
Fall 2006 Chem 116-003	0.53	0.49	0.56	0.49	84.5% ( $N = 76$ )
All sections of Chem 116 listed above (fall 2006 to fall 2008)	0.56	0.51	0.66	0.57	78.1% ( $N = 682$ )



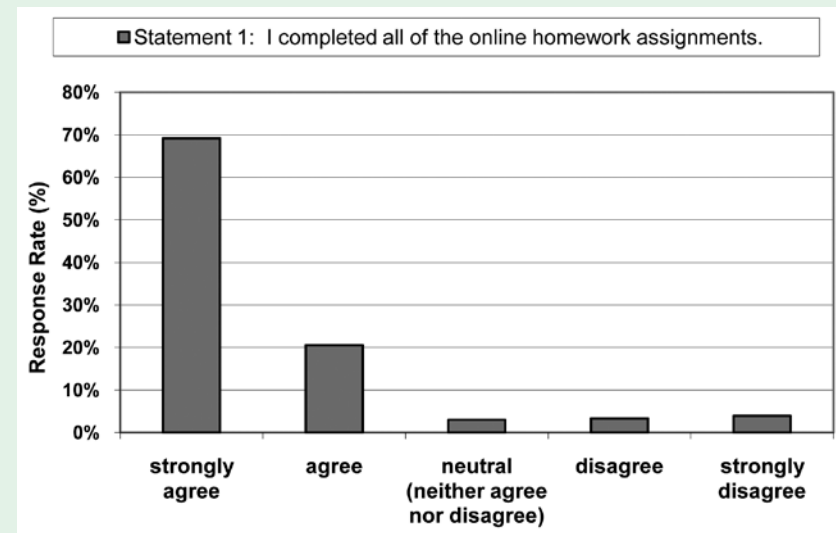
a generalized understanding of students' attitudes toward graded online homework. Demographic data (e.g., gender, class status) embedded in the survey and ACT and SAT math sub-scores indicate that these two populations were similar. All sections surveyed were taught by Instructor A.

### Online homework completion

As shown in Figure 1, 90% of off-semester second-term general chemistry students self-report that they completed all of the online homework assignments. This is encouraging because a predicted impediment to online homework completion was limited access to the internet. We found that student internet and computer access was a nonissue and did not prevent students from completing online homework assignments in a timely manner. However, as shown in Table 4, it was essential that students be rewarded for completing the online homework. Only 34.2% agreed (*strongly agreed* or *agreed*)

**FIGURE 1**

**Second-term general chemistry student response rate (%) in terms of agreement with statement 1. The total number of respondents for statement 1 was  $N = 331$ .**



that they would have completed the online homework for no grade reward, 63.0% completed the online homework because of the grade reward, and 49.8% did no other home-

work that was not worth a portion of the grade. Clearly, the majority of today's students are more motivated to complete homework that is worth a portion of the grade.

**TABLE 3**

**Average success rates and comparative statistics prior to and after implementation of online homework. Success rates after implementation of online homework include data from six semesters of second-term general chemistry classes, fall 2006 through spring 2009. Prior to implementation of online homework, success rates include data from 10 semesters, fall 2001 through spring 2006.**

Semester	Average success rate after online homework (fall 2006–spring 2009)	Average success rate before online homework (fall 2001–spring 2006)	Difference (after–before)	<i>p</i> value	Confidence interval (CI)
Fall semesters (off-semester)	56.3% <sup>a</sup> ( $N = 853$ ; 3 semesters)	52.6% <sup>b</sup> ( $N = 1,324$ ; 5 semesters)	3.7%	$0.025 < p < .05$	0.1%–7.3% (90% CI)
Spring semesters (on-semester)	66.4% <sup>c</sup> ( $N = 1,734$ ; 3 semesters)	56.5% <sup>d</sup> ( $N = 2,361$ ; 5 semesters)	9.9%	$p < .0005$	4.9%–14.9% (99.9% CI)
Fall and spring semesters combined	63.0% ( $N = 2,587$ ; 6 semesters)	55.1% ( $N = 3,685$ ; 10 semesters)	7.9%	$p < .0005$	3.8%–12.1% (99.9% CI)

<sup>a</sup>Instructor A taught 6 of 6 sections.

<sup>b</sup>Instructor A taught 7 of 10 sections.

<sup>c</sup>Four different instructors taught 9 different sections.

<sup>d</sup>Four different instructors taught 12 different sections.

## Online homework understanding

Although our students were completing the online homework assignments, we were interested in whether our students understood how to use the online homework as a learning tool. For instance, were students learning from mistakes and working out answers instead of guessing? It was encouraging to find that 60.2% of students indicated that they looked over the online homework assignments to learn from

their mistakes (statement 5 in Table 5). To check for survey internal consistency, we included the negative of this statement (statement 10) and found a similar result (i.e., 58.3% of students disagreed with the statement that they never tried to figure out mistakes). Even more encouraging was the fact that 90.9% of students indicated the use of pencil and paper to work out numerical answers before submission. In contrast, the fact that 35.0% of students admitted to a certain amount of

guessing is somewhat discouraging and is a matter that is being addressed by limiting the number of numerical multiple-choice questions and expanding the number of randomizable or algorithmic questions within online homework assignments.

To obtain specific information on how students were using the online homework as a learning tool, responses to the free-response question (“After incorrectly answering an online homework question on your first

**TABLE 4**

**Response rate (in %) to statements involving online homework completion as specified in statements 2–4.**

Statement	Strongly agree or agree	Neutral	Strongly disagree or disagree	Number of responses
2: I would have completed the online homework assignments even if they were not to be graded.	34.2%	30.3%	35.5%	330
3: I only completed the online homework assignments because they were worth a portion of my grade.	63.0%	15.3%	21.7%	327
4: Besides online homework and laboratory homework, I did none of the other homework recommended on the homework sheet.	49.8%	16.1%	34.0%	329

Note: Number of responses indicates the total number of students who responded to the particular statement. Responses of *strongly agree* and *agree* have been collapsed and are shown together; likewise, *strongly disagree* and *disagree* responses are shown together.

**TABLE 5**

**Response rate (in %) to statements involving online homework understanding as specified in statements 5–10.**

Statement	Strongly agree or agree	Neutral	Strongly disagree or disagree	Number of responses
5: I looked over the graded online homework in order to learn from my mistakes.	60.2%	18.2%	21.6%	329
6: I generally understood the questions within the online homework assignments.	78.9%	16.5%	4.6%	327
7: I could complete the online homework assignments with little outside help.	66.4%	21.2%	12.4%	330
8: I guessed at the answers to the online homework assignments.	35.0%	33.7%	31.3%	329
9: For numerical questions, I worked out the answers with pencil and paper before submitting an answer within the online homework assignment.	90.9%	5.7%	3.3%	331
10: I never tried to figure out my mistakes on questions I answered wrong within the online homework.	21.8%	19.9%	58.3%	331

Note: Number of responses indicates the total number of students who responded to the particular statement. Responses of *strongly agree* and *agree* have been collapsed and are shown together; likewise, *strongly disagree* and *disagree* responses are shown together.

attempt, what did you do? Did you guess for the remaining two attempts or did you seek help from the link or text? Explain.”) were coded and placed into categories (see Table 6). In all, 175 of 333 students (or 52.6%) who completed the survey provided written responses to this question. After incorrectly answering a question, students were reworking/checking their work (33.7%), seeking help from print/online resources (68.6%), and/or seeking help from another person (25.7%). These responses help to triangulate the Likert portion of the survey in which 60.2% of students indicated that they looked over the online homework to learn from their mistakes (see statement 5 in Table 5). Guessing as a last resort and guessing immediately after an incorrect answer was reported by 18.3% and 11.4% of students, respectively, for a minimum of 29.7% guessing at one time or another. Once again, this correlates with Likert responses to statement 8 in which 35.0% of students indicated some amount of guessing when completing online homework. Representative responses include:

- “I did the problem again, found where I went wrong, correctly did it, and got it right 95% of the time. I very rarely guessed unless I had completely no idea what was going on.”
- “If I thought I did it correctly & was confused I would first consult my notes, then ask a classmate, then consult the book, and lastly e-mail/visit the professor.”
- “I always worked the problems out on paper, so I looked back over it trying to find my mistake and if I couldn’t figure it out I would go to the link or the text.”
- “I usually tried to figure out what I did wrong by reviewing the text

or notes. I liked when it tried to explain what I did wrong because I knew what to fix. If all else failed, I usually asked a friend how it was done.”

- “I looked for help and did everything possible to figure it out. If I still couldn’t get it then I made an educated guess. If I still couldn’t get it, I left it blank and asked a friend for help.”
- “Guessed on first two attempts, then tried to solve.”
- “Usually if, I got it wrong the first time it was because I guessed so then I would really try and figure out what to do.”

### Online homework attitudes

As shown in Figure 2, student attitudes toward online homework were generally favorable with 80.2% (*strongly agree* and *agree*,  $N = 329$ ) indicating a positive experience overall. More insightful were responses to statements 13, 15, 17, and 18 in which surveyed students viewed the online homework as worth the effort (83.5%,  $N = 321$ ), relevant to what was presented in class (90.5%,  $N = 326$ ), challenging (83.4%,  $N = 325$ ), and more chemically thought provoking (79.0%,  $N = 329$ ).

To check for survey internal consistency, negative statements pertain-

**TABLE 6**

**Coded responses (in %) designating the frequency of each categorized response to the free-response question: “A. After incorrectly answering an online homework question on your first attempt, what did you do? Did you guess for the remaining two attempts or did you seek help from the link or text? Explain.”**

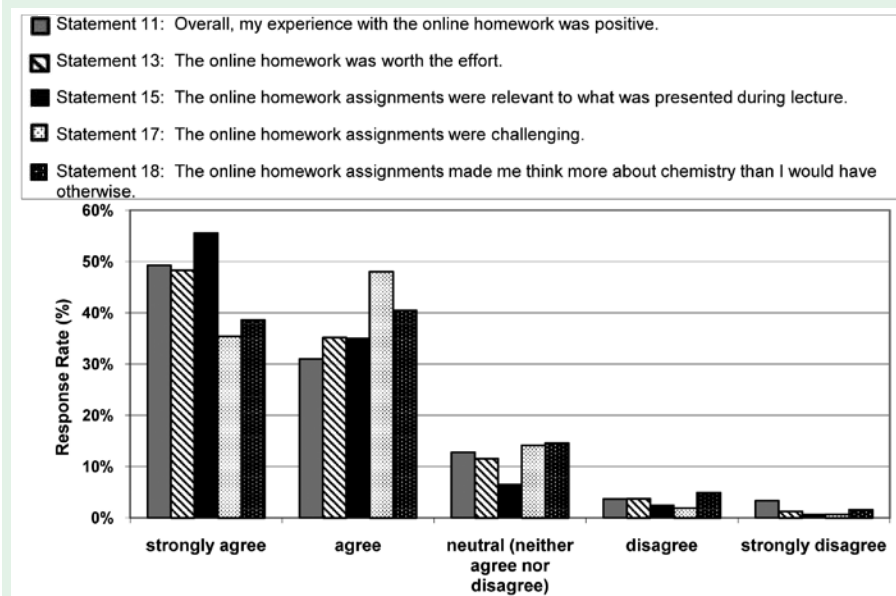
	Percent	N
<b>Category 1: Reworked/checked/backtracked</b>	33.7%	175
Subcategory a: reworked	10.9%	175
Subcategory b: checked/looked for error	23.4%	175
Subcategory c: backtracked	0.6%	175
<b>Category 2: Sought help from print/online source</b>	68.6%	175
Subcategory a: online link	24.6%	175
Subcategory b: text (online or printed)	43.4%	175
Subcategory c: lecture notes	25.1%	175
<b>Category 3: Sought help from person</b>	25.7%	175
Subcategory a: friend	11.4%	175
Subcategory b: professor	5.1%	175
Subcategory c: Chemistry Learning Center (CLC)	3.4%	175
Subcategory d: other students	2.9%	175
Subcategory e: study group	1.7%	175
<b>Category 4: Guessed as last resort</b>	18.3%	175
<b>Category 5: Guessed immediately</b>	11.4%	175
<b>Category 6: Never guessed</b>	1.7%	175

Note: A total of 175 of 333 students (52.6%) provided written responses to this question.

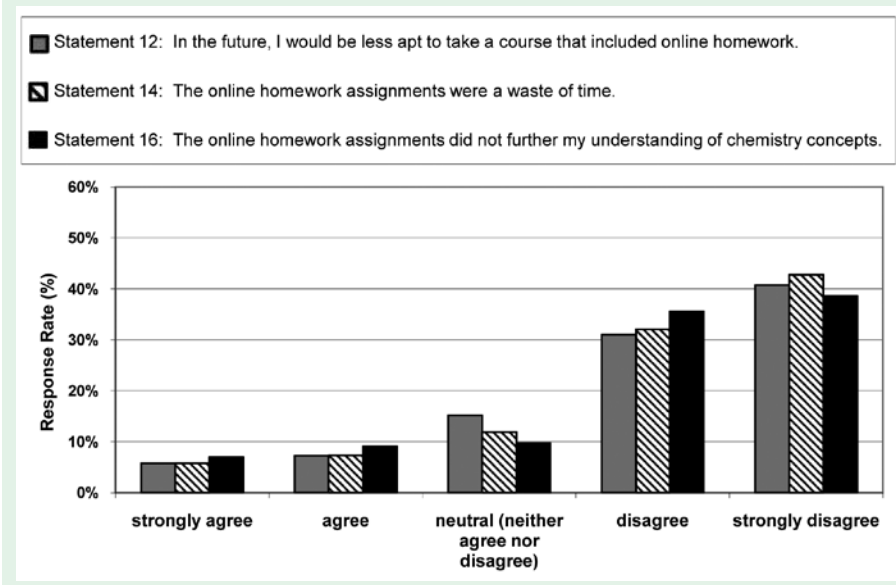


**FIGURE 2**

**Second-term general chemistry student response rate (%) in terms of agreement with the statements in 11, 13, 15, 17, and 18. The total number of respondents for statements 11, 13, 15, 17, and 18 was  $N = 329, 321, 326, 325,$  and  $329,$  respectively.**

**FIGURE 3**

**Second-term general chemistry student response rate (%) in terms of agreement with the statements in 12, 14, and 16. The total number of respondents for statements 12, 14, and 16 was  $N = 329, 327,$  and  $329,$  respectively.**



ing to students' online homework attitudes were embedded in this portion of the survey. Figure 3 indicates a general lack of agreement with the negative statements 12, 14, and 16. To summarize, only 13.1% would be less apt to take a course with online homework, 13.1% agreed that online homework was a waste of time, and 16.1% agreed that online homework did not further their understanding of chemistry concepts.

### Online homework study habits

According to 75.6% of second-term general chemistry students, weekly online homework deadlines encouraged more consistent and beneficial study habits: 50.9% self-report spending less time cramming for exams, 53.9% felt more prepared for exams, and 77.2% spent more time doing homework for chemistry than for other classes (see Figure 4). Negative study habits of pulling all-nighters and studying chemistry only on days that online homework was due were reported by 23.8% ( $N = 323$ ) and 37.7% ( $N = 324$ ) of surveyed students, respectively. Similar to the survey results of Charlesworth and Vician (2003), we found that the majority of our students (61.0%;  $N = 323$ ) self-reported working alone to complete the online homework, and 38.2% ( $N = 325$ ) reported working in a group.

More detailed information on how online homework affected students' study habits was obtained from written comments to the free-response question: "Has use of the online homework changed your chemistry study habits? If so, in what way? Do you study chemistry more or less?"

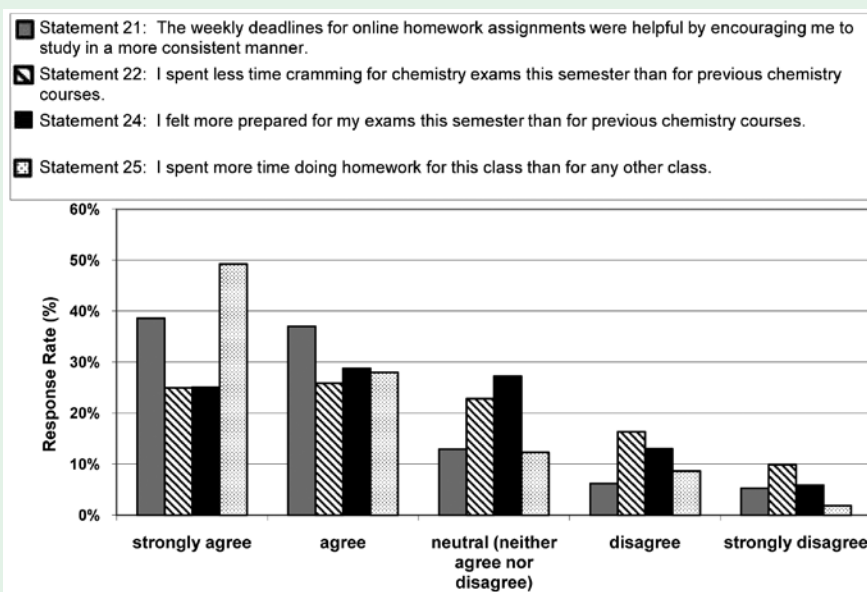
Do you spread out your chemistry study over more days or just study chemistry on the days that the online homework is due?" A total of 120 of 333 students (36.0%) provided written comments that were coded and placed into categories as shown in Table 7. The majority of students indicated that the online homework helped to improve their study habits (67.5%) by making them study more (29.2%), increasing the frequency of their study (41.7%) and reducing the amount of cramming (11.7%).

This correlates well with the Likert responses to statement 21 in which 75.6% of students reported that online homework made them study in a more consistent manner. Conversely, only 3.3% of students indicated that the online homework adversely affected their study habits. Representative comments from students with study habits categorized as improved include:

- "I studied much more. I spread out my studying but the online homework made my knowledge more in depth [sic]."
- "I realize that you must complete chemistry problems repetitively to learn the concept instead of memorizing."
- "Yes, it has. It actually improved my study habits for chem. pushing me to actually work out questions w/pen + paper. It helped me to realize [sic] that working out questions is more effective and the way you should study them than just relying on reading over your notes. Yes, I spread out study time better throughout the week [sic]."
- "Yes, I applied way more time to chemistry. I learned the benefits

FIGURE 4

**Second-term general chemistry student response rate (%) in terms of agreement with the statements in 21, 22, 24, and 25. The total number of respondents for statements 21, 22, 24, and 25 was  $N = 324, 324, 323,$  and  $325,$  respectively.**



of studying progressively instead of just the night before. I liked being able to do a little homework at a time (between classes, etc.). So I didn't get burnt out [sic] + learned way more."

- "The online homework has helped me study chemistry continually instead of cramming. I study chemistry much more now in a healthier more adequate way."
- "I study chemistry less because the online helps me retain and understand the material better. It hasn't changed my study habits though. I still wait for the last minute."

Although most of the comments to this question indicated improved study habits with online homework, there were several negative comments (3.3%). Representative negative comments are:

- "I read the textbook & try the hw which is usually impossible to do. I usually run out of time."
- "I feel that the online homework hinders my work in other classes. I can't study for tests on days that are close to due dates of online homework."

This is unfortunate and in general indicates a lack of time management on the part of the student rather than any real or imagined adverse affect of online homework on student study habits.

### Online homework perceived grades

It was expected that students would see the value of completing online homework because greater quality time-on-task leads to improved understanding of chemistry content.

To get at students' opinions of the value added by online homework completion, we asked students about its effect on their grades. These results are summarized in Table 8. Approximately half (52.2%) of students agreed that online homework helped to improve their exam scores, whereas 61.5% agreed that it improved their letter grade. Second-term general chemistry students were overwhelming (85.7% strongly agreed/agree) in their recommendation that online homework should be used for future general chemistry classes.

### *Instructor: Online homework use and qualitative perceptions*

Our instructors have willingly embraced the use of online homework since spring 2007. We are presently using online homework in the teach-

ing of all large-enrollment freshman- and sophomore-level general chemistry coursework. Moreover, two of our instructors have developed and are delivering in-house online homework to students in preparatory chemistry classes. Grading of paper-based homework in preparatory chemistry had become overly burdensome for both instructors and graders alike. All instructors point to the incredible amount of time savings for the instructor and grader as reason enough to use online homework. Furthermore, our instructors recognize that online homework provides students with immediate feedback, something that is not possible with hand-graded homework.

### **Conclusion**

Overall, correlations between online homework averages and grade

components were mildly positive but weaker than correlations between quiz averages and grade components. The allowance for multiple attempts at online homework questions (maximum of three attempts per question), so as not to penalize students for the learning process, may have been a contributing factor that weakened these correlations. However, replacing quizzes directly by online homework, significantly improved ( $p < .0005$ ) success rates in second-term general chemistry despite steady increases in university and freshmen enrollments. This provides further verification that (1) "graded" homework has a positive impact on student learning (Cheng et al. 2004; Fynnewever 2008; Cooper, Robinson, and Patall 2006) and (2) increased student time-on-task enhances learning (Varma-Nelson and Coppola 2004; Cooper and Valentine 2001; Keith, Diamond-Hallam, and Fine 2004; Keith and DeGraff 1977). Survey results indicate that the majority of students completed the online homework assignments (90%) albeit mainly for the grade reward (63.0%). However in keeping with the findings of other researchers, a significant percentage of students (34.2%) would have completed the online homework for no grade benefits (Penn, Nedeff, and Gozdzik 2000; Freasier, Collins, and Newitt 2003). Of particular interest were issues not previously addressed in the online homework literature (Penn, Nedeff, and Gozdzik 2000; Freasier, Collins, and Newitt 2003; Bonham, Beichner, and Dear-dorff 2001; Bressoud 2009; Cheng et al. 2004; Fynnewever 2008; Cole and Todd 2003; Arasasingham et al. 2005; Charlesworth and Vician 2003; Dori and Barak 2003), such as (1) did students understand how to use the online homework as a learning tool and (2) were students learning from their

**TABLE 7**

**Coded responses (in %) designating the frequency of each categorized response to the free-response question: "B. Has use of the online homework changed your chemistry study habits? If so, in what way? Do you study chemistry more or less? Do you spread out your chemistry study over more days or just study chemistry on the days that the online homework is due?"**

	Percent	N
<b>Category 1: Improved study habits</b>	67.5%	120
Subcategory a: study more	29.2%	120
Subcategory b: study more often/frequently/spread study over period of days	41.7%	120
Subcategory c: less or no cramming	11.7%	120
Subcategory d: understand chemistry better	13.3%	120
Subcategory e: feel more prepared	1.7%	120
<b>Category 2: Study habits stayed the same</b>	23.3%	120
Subcategory a: studied only the day online homework due	8.3%	120
<b>Category 3: Adversely affected study habits</b>	3.3%	120
Subcategory a: hindered work in other classes	1.7%	120
Subcategory b: online homework difficult/waste of time	1.7%	120
Subcategory c: ran out of time to complete	0.8%	120

Note: A total of 120 of 333 students (36.0%) provided written responses to this question.

mistakes and working out answers instead of guessing? A large majority of our students self-reported using one or more of a suite of effective problem-solving approaches: using paper and pencil to work out numerical answers (90.9%), reworking/rechecking, and seeking help from print/online sources and/or another person for questions marked as incorrect. Guessing was limited; a maximum of 35% of the class admitted to guessing.

Online homework attitudes were generally positive, with a large majority of students viewing the online homework favorably (80.2%), as worth the effort (83.5%), relevant (90.5%), challenging (83.4%), and chemically thought provoking (79.0%). Similar views of online homework use were reported by several researchers (Freasier, Collins, and Newitt 2003; Fynewever 2008; Arasasingham et al. 2005; Charlesworth and Vician 2003). However, we also sought to understand students' perceptions of how online homework affected their study habits. Beneficial study habits of more consistent study (75.6%), less cramming (50.9%), better preparation (53.9%), and completing more homework (77.2%) were reported by a majority of our students. More telling is the

fact that students were overwhelming in their recommendation that online homework should be used for future classes (85.7%). Although our results indicate that online homework improves student success in second-term general chemistry (relative to quizzes and ungraded homework) and that students are generally receptive to its use, we have no evidence to support the use of online homework over conventional hand-graded homework. However, we have found no overtly negative effects on student study habits or attitudes toward the course with online homework use and can point to the incredible amount of time savings for the instructor as reason enough to use online homework (Penn, Nedeff, and Gozdzik 2000; Bressoud 2009; Fynewever 2008; Cole and Todd 2003; Dori and Barak 2003). We are of the opinion that online homework systems work well because, as stated by Pienta et al. (2001, p. 368), "navigational aspects" of internet-accessible materials "hide the amount of material covered" thus increasing student time-on-task unbeknownst to the student. ■

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TABLE 8

Response rate (in %) to statements involving online homework perceived grades and recommendations as specified in statements 30–32.

Statement	Strongly agree or agree	Neutral	Strongly disagree or disagree	Number of responses
30: I received higher scores on the four hourly exams due to my completion of the online homework.	52.2%	25.6%	22.2%	320
31: I will receive a higher letter grade in general chemistry due to my completion of the online homework assignments.	61.5%	21.4%	17.1%	322
32: I recommend that the online homework assignments be used for future general chemistry classes.	85.7%	8.1%	6.2%	321

Note: Number of responses indicates the total number of students who responded to the particular statement. Responses of *strongly agree* and *agree* have been collapsed and are shown together; likewise, *strongly disagree* and *disagree* responses are shown together.

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