Factors Influencing Passing Rates for First-Semester Organic Chemistry Students

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Abstract: A five-year study of the factors affecting the passing rates of first-semester organic chemistry students at a public university in California is reported. Student attitudes, perceptions, and attributes were examined at the beginning of the course (N = 234) and at the end of the course (N = 161). There is a definite correlation of increased study time and student expectations with passing rate. One counterintuitive result is that there appears to be no correlation between the amount of time since the last college-level chemistry course was taken and the passing rate. In addition, another result hints that for the subgroups in this study, there seems to be no affect on the passing rate for students having one versus two semesters of general chemistry preparation. These two results may imply that, at least for the group of students in this study, the exact content preparation of students may not play as large a role in determining the passing rate in first-semester organic chemistry as other student attributes, such as study skills and motivation.

Introduction

Over the past decade or so, there have been a number of efforts to address the low success rate of students in the organic chemistry course. One such effort has focused on creating a more active learning environment [1]. Paulson [2] and Hagen [3] have reported the success they have had increasing the passing rates of students at large public universities by incorporating cooperative learning into the classroom. Bradley, et al. [4] also report on their use of this method at a large private university. Huddle [5] has proposed the use of poster sessions to enhance student learning, and Sartoris [6] has discussed the merits of a two-cycle approach to teaching students organic chemistry. Another tactic has been to use Web-based assignments prior to class to improve the preparation of students for the lecture, as was described by Collard, et al. [7]. Lastly, an extensive study by Tien, et al. [8] has looked at the effect that peer-led team learning instruction can have on the passing rates in the organic chemistry course.

Another change in the organic chemistry curriculum has been a small but significant trend to abandon the traditional two-semester sequence of general chemistry prior to organic chemistry. Examples of programs that have undergone this change are at the University of Michigan [9, 10] and Gonzaga University [11]. In the former case, these modifications have included eliminating general chemistry altogether for some student groups and beginning with a modified organic chemistry course that emphasizes structure and reactivity. In the latter case, the strategy has been to modify the introductory sequence to utilize only a single semester of the general chemistry course before students enter the organic chemistry course.

One other approach to dealing with the problem of low passing rates in organic chemistry is to try to identify those factors that may be predictors of student success. This has been reported in a number of studies for general chemistry (see, for example, references 12–14). One investigation of predictors of success for nursing students in a one-semester organic and biochemistry course was reported by Van Lanen, et al. [15]. This work focused mainly on the preparation and other characteristics of students and how they relate to passing the course.

In this present work, a number of attributes of first-semester organic chemistry students are examined for first-time organic chemistry students (N = 234). These factors are then related to the passing rate of students in this course. The data gathered included student attitudes, study habits, perceptions, and backgrounds. The goal of this work was to elucidate common attributes of successful first-time organic chemistry students.

Procedure

The students sampled came from the first-semester organic chemistry class (Chemistry 201) at California State University San Marcos (CSUSM) from 1997–2001. Precourse surveys (Supporting Material 1) were distributed in the first few weeks of the semester by the investigator. A series of basic background and attitude questions were asked. Students were given the relevant background information as to the purpose of the survey and were asked to give their permission for the investigator to have access to their final grades for the course. For all years surveyed 98% of the students gave their permission for grade access; therefore, it is believed that the sample of students is representative of the organic chemistry students in the course at CSUSM. A postcourse survey (Supporting Material 2) was also distributed to the students and completed during the last two weeks of the semester.

The organic chemistry course over the period studied was taught by two different instructors. One instructor taught the course for all five years, while the second instructor taught a second section for four of these years. Only in 1997, when the class size was 69, was the class size ever more than 50 students. Because both instructors were experienced permanent

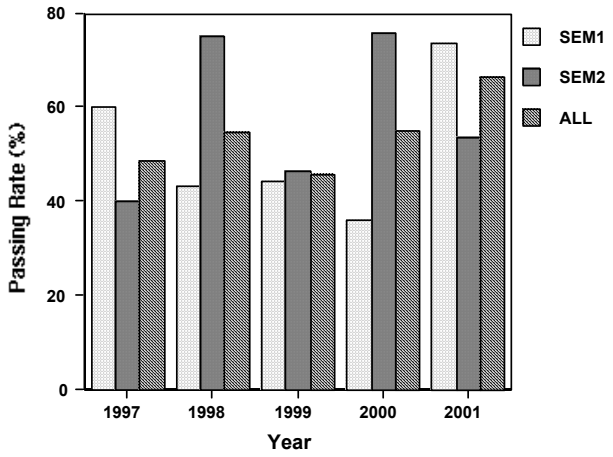

Figure 1. Graph of "passing rate" versus year for SEM1 and SEM2.

Table 1. Background of Participants from Precourse Survey[a]

Item	ALL	SE M1	SE M2	SEM1 versus SEM2
Gender				$\chi^2 = 0.103$, df =1, $p = 0.75$
Male	34.6	36.8	33.3	
Female	65.4	63.2	66.7	
Class				$\chi^2 = 67.6$, df =4, $p < 0.001$
Freshman	19.2	41.5	0.0	
Sophomore	18.4	26.4	8.0	
Junior	49.6	22.6	72.0	
Senior	10.3	7.5	17.3	
Major				$\chi^2 = 1.12$, df =2, $p = 0.57$
Biology	73.9	72.6	76.0	
Chemistry	16.7	16.0	17.3	
Other	9.4	11.3	6.7	
Age				$\chi^2 = 54.0$, df =4, $p < 0.001$
≤ 20	35.9	63.2	9.3	
21-22	19.2	13.2	24.0	
23-24	18.4	11.3	28.0	
25-26	9.0	3.8	13.3	
≥ 27	17.5	8.5	25.3	
English Speaker				$\chi^2 = 0.016$, df = 1, $p = 0.90$
Yes	72.2	70.8	77.3	
No	11.1	10.4	9.3	
No data	16.7	18.9	13.3	
How long since last chemistry course				$\chi^2 = 136.5$, df = 3, $p < 0.001$
≤ 6 mo	61.1	96.2	10.7	
> 6 mo but ≤ 1 yr	12.0	0	26.7	
> 1 yr but ≤ 2 yr	13.7	3.8	29.3	
> 2 yr	13.2	0	33.3	
Semester Units Enrolled				$\chi^2 = 2.85$, df = 4, $p = 0.58$
≤ 6	0.9	0.9	1.3	
7-9	8.5	6.6	12.0	
10-12	22.2	20.8	25.3	
13-15	48.7	52.8	42.7	
≥ 16	19.7	18.9	18.7	

[a]Results given by percentage of respondents. (ALL: $N = 234$; SEM1: $N = 106$; SEM2: $N = 75$).

faculty who received high ratings from students, no attempt was made to separate out instructor influence on the results.

In this work, a student was considered to have passed the first semester of organic chemistry if they received a grade of C or better. This measure was used because at CSUSM this is the grade requirement for chemistry or biology majors enrolled in this course. Withdrawals are counted as "no passes" in this work.

All data analysis was done using SPSS, Version 10.0 for the Macintosh [16]. Because most of the collected data was nominal, the statistical method used was a chi-squared test [17, 18] and the measure for statistical significance used was a value of $p < 0.05$. In cases of one degree of freedom, the more stringent continuity correction was applied in the calculation of the p value [18]. In reporting the results, the values of χ^2, the number of degrees of freedom (df), and p will be given.

Population

The data was gathered at the California State University San Marcos (CSUSM) which is one of over 20 four-year public universities in the CSU system. CSUSM is one of the newer campuses in the system (est. 1989). It began offering upper-division chemistry major courses in 1993 and lower-division classes in 1995. The campus at the time of this study was 100% commuter student in nature. In addition, as is typical in the CSU system, approximately two-thirds of students attending were transfer students from the community college system. A total of 318 student surveys were collected in the precourse portion of this work. Only data from first-time organic students were analyzed. Throughout this report, reference will be made to three groups designated as ALL, SEM1, and SEM2. The ALL group contained every first-time organic student (N = 234), while SEM1 and SEM2 are subgroups of the ALL group. SEM1 (N = 106) represents first-time organic chemistry students having taken **only** one semester of college-level general chemistry, which was at CSUSM. SEM2 (N = 75) consists of first-time organic chemistry students who completed a two-semester general chemistry course at another institution, but did not take the one-semester general chemistry course at CSUSM.

Given the relatively small number of students falling into ALL, SEM1, and SEM2 in any particular year, it was decided that the data for the nine sections taught over the five-year period would be pooled. In terms of the ALL group, the passing rate for students in the first semester of organic chemistry varied from 46% to 67%. Although this range was large, statistical analysis showed no significant differences between the years over this period ($\chi^2 = 4.67$, df = 4, $p = 0.32$). The yearly fluctuations in passing rate for the separate SEM1 and SEM2 varied from 36% to 74% for SEM1 and 40% to 76% for SEM2. Although these ranges are large, the yearly fluctuations for either group were not significant (SEM1: $\chi^2 = 8.17$, df = 4, $p = 0.085$; SEM2: $\chi^2 = 6.80$, df = 4, $p = 0.15$). In addition, as seen in Figure 1, no systematic pattern was observed when comparing the yearly passing rates of the groups. In two of the years, SEM1 had a passing rate greater than 20% of SEM2, and in two other years SEM2 had a passing rate greater than 20% of SEM1.

Given in Table 1 are background data for the students surveyed, along with some statistical comparisons between SEM1 and SEM2. For the categories of gender, major, native English speaker, and units enrolled, there are no differences in these two subgroups. It is interesting to note that about two-thirds of all the organic students were female. This is reflective of the overall student population at CSUSM.

Table 2. Student Attitudes and Perceptions from Precourse Survey[a]

Item	ALL	SEM1	SEM2	SEM1 versus SEM2
Previous Chemistry Experience				$\chi^2 = 2.00$, df = 3, $p = 0.57$
excellent	22.6	23.6	20.0	
good	46.6	49.1	44.0	
fair	27.8	23.6	33.3	
poor	2.6	2.8	2.7	
Personal Interest in Organic				$\chi^2 = 3.57$, df = 4, $p = 0.47$
very high	11.1	9.4	8.0	
high	32.1	34.9	33.3	
moderate	38.0	34.0	44.0	
low	7.3	7.5	6.7	
don't know	11.1	14.2	6.7	
Preparation in basic chemistry				$\chi^2 = 3.88$, df = 3, $p = 0.27$
excellent	15.0	17.9	9.3	
good	50.0	49.1	46.7	
average	32.5	30.2	41.3	
poor	2.6	2.8	2.7	
Success and Grade				$\chi^2 = 7.47$, df = 2, $p = 0.024$
A	51.7	40.6	60.0	
B	45.3	56.6	36.0	
C	3.0	2.8	4.0	

[a]Results given by percentage of respondents. (ALL: N = 234; SEM1: N = 106; SEM2: N = 75).

Table 3. Precourse Survey Responses and Passing Rate[a]

Item	Pass	No Pass	
Preparation in basic chemistry			
ALL			$\chi^2 = 9.57$, df = 3, $p = 0.023$
excellent	77.1 (27)	22.9 (8)	
good	53.0 (62)	47.0 (55)	
average	46.1 (35)	53.9 (41)	
poor	50.0 (3)	50.0 (3)	
SEM1			$\chi^2 = 15.92$, df = 3, $p = 0.001$
excellent	89.5 (17)	10.5 (2)	
good	48.1 (25)	51.9 (27)	
average	40.6 (13)	59.4 (19)	
poor	0.0 (0)	100.0 (3)	
SEM2			$\chi^2 = 2.15$, df = 3, $p = 0.54$
excellent	57.1 (4)	42.9 (3)	
good	65.7 (23)	34.3 (12)	
average	54.8 (17)	45.2 (14)	
poor	100.0 (2)	0.0 (0)	
Time since last chemistry course			
ALL			$\chi^2 = 3.48$, df = 1, $p = 0.06$
< 1 yr.	50.3 (86)	49.7 (85)	
≥ 1 yr.	65.1 (41)	34.9 (22)	
SEM2			$\chi^2 = 1.72$, df = 1, $p = 0.19$
< 1 yr.	50.0 (14)	50.0 (14)	
≥ 1 yr.	68.1 (32)	31.9 (14)	
Success and Grade			
ALL			$\chi^2 = 21.63$, df = 1, $p < 0.001$
A	69.4 (84)	30.6 (37)	
B	37.7 (40)	62.3 (66)	

[a]Results given by percentage of respondents, absolute numbers of individuals given in parentheses (ALL: $N = 234$; SEM1: $N = 106$; SEM2: $N = 75$).

As expected, because SEM2 consisted completely of transfer students, there were significant differences between this group and SEM1 in terms of college class status ($\chi^2 = 67.6$, df = 4, p < 0.001) and age ($\chi^2 = 54.0$, df = 4, $p < 0.001$). For SEM2, the typical age was in the early to mid-twenties, with one-quarter being over the age of 27 years. On the other hand, almost two-thirds of SEM1 individuals were ≤ 20 years of age, although almost 60% had a class status of sophomore, junior, or senior. There was also a significant difference in the time since a previous chemistry course was taken for these two groups ($\chi^2 = 136.5$, df = 3, $p < 0.001$). It is not surprising that SEM1 showed a dramatically shorter time since the last chemistry course because students who successfully passed the CSUSM general chemistry course would be expected to go directly to the organic course the next semester. Conversely, transfer students taking a two-semester general chemistry sequence at another college or university would be expected to have a longer time lag between courses. What is perhaps most surprising is that almost two-thirds of the SEM2 students have waited more than a year to enroll in organic chemistry with one-third waiting two or more years.

Given in Table 2 are results for some questions gauging students' attitudes and perceptions. There were no significant differences between SEM1 and SEM2 in terms of "previous chemistry experience," "personal interest in organic chemistry," or preparation in basic chemistry." Overall, a large percentage of the students indicated that their previous chemistry experience was either "good" or "excellent" (ALL: 69%; SEM1: 73%; SEM2: 64%). In terms of interest in organic chemistry, less than half of the students indicated their interest was "very high" or "high." This may be due to a lack of information about organic chemistry, or because the majority of the students were not chemistry majors.

There was a significant difference between the SEM1 and SEM2 groups in relation to the students' definitions of "success" in terms of grade ($\chi^2 = 7.47$, df = 2, $p = 0.024$). In SEM1 and SEM2, the students overwhelmingly equated success with an "A" or "B" grade; however, 60% of the students in SEM2 defined success in the course as an "A", while that percentage in SEM1 was only 41%. There is obviously a difference in personal expectations between these two groups. This may simply be related to the fact that students who have been in college longer have more confidence in their ability to receive an A. In fact, the numbers seem to support this hypothesis. When all students are aggregated into upper division (junior, senior, and post-baccalaureate) and lower division (freshman and sophomore), there is a significant difference in the upper-division students equating success with an "A" (57%) compared with the lower-division students (42%) ($\chi^2 = 8.30$, df = 2, $p = 0.016$).

What Student Factors Affect the Passing of Organic Chemistry?

Precourse Questions. Few definitive attributes of successful students can be obtained in a short survey as was given here, but some useful information may be extracted. Some selected results are given in Table 3. For the ALL group, factors that did not show a significant correlation with passing rate were: "gender" ($\chi^2 = 2.33$, df = 1, $p = 0.13$), "class standing" ($\chi^2 = 1.27$, df = 4, $p = 0.87$), "college major" ($\chi^2 = 2.28$, df = 2, $p = 0.32$), "age" ($\chi^2 = 5.66$, df = 4, $p = 0.23$), "English as native language" ($\chi^2 = 0.65$, df = 1, $p = 0.42$), and "total units enrolled" ($\chi^2 = 2.19$, df = 4, $p = 0.70$). This is also

true when the SEM1 and SEM2 results are considered individually. For the areas of "major" and "English as native language", the numbers of students reported for some of the categories were low; therefore, the sample may not have had sufficient numbers to reveal a statistical correlation.

There were two factors from the precourse survey that showed a significant correlation with passing rate for all students. These were "preparation in basic chemistry" (χ^2 = 9.57, df = 3, p = 0.023) and "success and grade" (χ^2 = 23.24, df = 2, $p < 0.001$). In order to further substantiate these results additional analyses were performed on these questions by individually testing the SEM1 and SEM2 groups and also by aggregating some of the responses.

Responses to the question about "preparation in basic chemistry" indicate that there was a significant correlation of passing rate with response for SEM1 (χ^2 = 15.92, df = 3, p = 0.001), but not for SEM2 (χ^2 = 2.15, df = 3, p = 0.54). A close look at the data in Table 3 shows that in the SEM1 group, a much larger percentage of respondents rating their preparation as "excellent" actually did "pass." It should be noted that in absolute numbers, this corresponds to 17 individuals who passed and rated their preparation as "excellent" and only 2 individuals who did not pass, yet rated their preparation as "excellent". Aggregation of the data into the responses "excellent/good" and "average/poor" did not show a strong correlation of this item with passing rate for ALL (χ^2 = 2.73, df = 1, p = 0.10) and SEM2 (χ^2 = 0.12, df = 1, p = 0.72), although the results for SEM1 (χ^2 = 3.71, df = 1, p = 0.054) still hinted at a possible correlation. There is not strong evidence, however, to indicate that a student's perception of their "preparation in basic chemistry" is correlated with passing rate.

For the question relating "grade" and "success", further analysis considered only responses for grades "A" and "B", because these made up 94% of the responses. Using this data, significant differences remained when the "desired grade" was correlated with passing rate. This was true for ALL (χ^2 = 21.63, df = 1, $p < 0.001$) and SEM1 (χ^2 = 17.2, df = 1, $p <$ 0.001), but less so for SEM2 (χ^2 = 3.61, df = 1, p = 0.057). It seems to be the case that students who equate success in organic chemistry with a grade of "A" seem to be more likely to pass the course; however, it is not clear what the exact reason for this may be. Perhaps the student who has higher expectations works harder than one who would be "satisfied" with a grade of "B." An alternate hypothesis is that students accustomed to getting "A" grades in their course work have a more realistic expectation of the necessary level of work and commitment that this success requires. These results are consistent with a previous study of high school physics students that indicated that student expectations are correlated with course performance [19].

Although "previous experience in chemistry" did not show any correlation with "pass" rate for the ALL group (χ^2 = 5.66, df = 3, p = 0.13), further analysis was done. When the responses for "previous experience in chemistry" are separated into groups, there appears a significant correlation with passing rate for SEM1 (χ^2 = 9.16, df = 3, p = 0.027), but not for SEM2 (χ^2 = 5.73, df = 3, p = 0.12). The correlation for all groups disappears, however, when the responses for "excellent"/"good" and "fair"/"terrible" are aggregated; therefore, there is not a strong case to show a correlation with "previous experience in chemistry" and passing rate.

Analysis of the data based upon "personal interest in organic chemistry" showed no significant correlation with passing rate (χ^2 = 7.64, df = 4, p = 0.11). Given the large range of possible answers from the survey, the responses were aggregated into "very high/high" and "moderate/low". Re-analysis showed a significant correlation of "interest" in the topic with passing rate among those with highest interest; 62% of those with highest interest passed compared to 48% for those with lower interest (χ2 = 3.91, df = 1, p = 0.048). This correlation was not apparent in either SEM1 or SEM2 separately; therefore, there is not a strong case to suggest that this quantity is correlated with passing rate.

The variable "time since last chemistry course was taken" did not show a correlation with passing rate for ALL (χ^2 = 4.43, df = 3, p = 0.22). This data is somewhat skewed by the percentage of students in SEM1 who fall in the ≤ 6 months category (96%). Analysis of SEM2 (χ^2 = 2.76, df = 3, p = 0.43) only, which has a larger spread in responses, still showed no statistical correlation. Because this result seems to be counterintuitive, further analysis was done in which the respondents were categorized as either having taken their last chemistry course "< 1 year" or "≥ 1 year". This data is presented in Table 3. This aggregation increased the numbers in each category. The analysis gave the following results: ALL (χ^2 = 3.48, df = 1, p = 0.06) and SEM2 (χ^2 = 1.72, df = 1, p = 0.19).

The above result is somewhat surprising, because it might be anticipated that students who had more recently studied chemistry concepts should perform significantly better in organic chemistry. In fact, the results above suggest, at best, a very weak correlation. Closer examination, however, reveals that any potential correlation is contrary to expectations. The greater passing rate (65%) was observed for students falling in the "≥1 year" category, compared to the "< 1 year" category (50%). Because students tend to forget chemistry content over time, this result implies that factors other than content knowledge are important for success in organic chemistry. Perhaps once a very basic knowledge of chemical concepts is obtained, the more important attributes for student success in this course are motivation [9], study habits [1] and acclimation to the chemistry culture [14].

All the previous conclusions were reached using the data collected from the precourse surveys from students enrolled in and attending the organic chemistry course at the beginning of the semester. As will be discussed in detail in the next section, the students remaining in the course when the postcourse survey data were collected are demographically the same, but have a different passing rate. This leads to the question as to whether analysis of the precourse data for students who also returned postcourse surveys would lead to different results. In all cases the general conclusions reached from the analysis of all the precourse surveys also holds true if only the data for students attending at the end of the semester is examined.

Postcourse Questions. Presented in Table 4 are selected data for students completing the postcourse survey. Due to attrition and absences, the number of postcourse surveys collected was only 70% that for the precourse surveys. In the discussion that follows, this will be denoted by modifying the names of the groups to ALLP (N = 161), SEM1P (N = 74), and SEM2P (N = 53). The students attending at the end of the semester are demographically similar in terms of gender, age, class, etc. to those responding to the precourse survey, but are

Table 4. Postcourse Survey Responses and Passing Rate (ALLP)[a]

Item	Pass	No Pass	
Weekly Average Hours studying/Reading			$\chi^2 = 7.96$, df = 3, $p = 0.047$
≥ 7	82.5 (33)	17.5 (7)	
5-6	75.0 (45)	25.0 (15)	
3-4	56.9 (29)	43.1 (22)	
≤ 2	70.0 (7)	30.0 (3)	
Participated in Study Groups			$\chi^2 = 1.60$, df = 3, $p = 0.66$
≥ 2 times/week	63.2 (12)	36.8 (7)	
1 time/week	68.5 (37)	31.5 (17)	
1 time/month	77.1 (37)	22.9 (11)	
never	70.0 (28)	30.0 (12)	
Experience in Organic Chemistry			$\chi^2 = 19.79$, df = 3, $p = <0.001$
excellent	88.2 (30)	11.2(4)	
good	78.4 (58)	21.6 (16)	
fair	51.1 (23)	48.9 (22)	
terrible	37.5 (3)	62.5 (5)	
Personal Interest in Organic Chemistry			$\chi^2 = 12.27$, df = 2, $p = 0.002$
higher	85.3 (58)	14.7 (10)	
about the same	60.0 (42)	40.0 (28)	
lower	59.1 (13)	40.9 (9)	

[a]Results given by percentage of respondents, absolute numbers of individuals given in parentheses ($N = 161$).

distinctly different based on passing rate. Postcourse respondents passed at a rate of 71% as compared to 54% for precourse respondents. Few postcourse variables showed a significant correlation with the passing rate, except for expected items such as "grade expected," "study habits," and "satisfaction with performance." Only a few variables will be discussed in detail here.

"Participation in study groups" ($\chi^2 = 1.60$, df = 3, $p = 0.66$) and the associated variable "seeking help from other students" ($\chi^2 = 5.66$, df = 3, $p = 0.13$) did not significantly affect the passing rate for the ALLP group in this course. This also held true when the SEM1P and SEM2P groups were analyzed separately. Although informal study groups are in general a good idea for students to tackle difficult material [2, 20, 21], they are obviously not a cure-all. Which individuals are in your group and how it runs are two important variables in addition to how often you meet.

The "number of hours per week that the student worked at a paying or nonpaying job" showed no correlation with the passing rate for ALLP ($\chi^2 = 2.48$, df = 3, $p = 0.48$). Interestingly, 45% of students surveyed at the end of the course worked more than 20 hours per week and 71% worked more than 10 hours per week. This high number of hours is not unusual for a campus such as CSUSM where students tend to be at least partially supporting themselves. The hours worked was essentially the same for both SEM1P and SEM2P, and no correlation between hours worked and passing rate was seen for these groups individually (SEM1P: $\chi^2 = 3.58$, df = 3, $p = 0.31$; SEM2P: $\chi^2 = 2.40$, df = 3, p = 0.49). Another variable "total number of units enrolled in" also showed no correlation with passing rate ($\chi^2 = 3.74$, df = 4, $p = 0.44$) for ALLP. Even upon aggregating the data to give two categories (< 13 units and ≥ 13 units), there was no correlation with this variable ($\chi^2 = 1.22$, df = 1, $p = 0.27$).

As might be expected, a correlation does exist between passing rate and the number of hours per week reading or studying ($\chi^2 = 7.96$, df = 3, $p = 0.047$). Of those respondents present at the end of the semester, 58% of those stating that they had studied four or fewer hours per week passed, while the percentage was 78% for those studying five or more hours per week. These results do not hold up for the SEM1P ($\chi^2 = 4.96$, df = 3, $p = 0.17$) and SEM2P ($\chi^2 = 6.04$, df = 3, $p = 0.11$) groups separately, but this may be due to sample size. If students are aggregated into two groups (< 5 hours and ≥ 5 hours per week), then the following results are obtained for the groups: ALLP: $\chi^2 = 6.27$, df = 1, $p = 0.012$; SEM1P: $\chi^2 = 3.57$, df = 1, $p = 0.059$; SEM2P: $\chi^2 = 4.32$, df = 1, $p = 0.038$. Although these results are not particularly enlightening, they do substantiate the instructor mantra of telling students that reviewing material often will help them succeed.

Other data in Table 4 address student attitudes and perceptions of the organic chemistry class. As expected, students rating of their experience in the course depends on whether they "pass" or "fail" ($\chi^2 = 19.79$, df = 3, $p < 0.001$). In addition, there are significant differences in the changes in "personal interest in organic chemistry" ($\chi^2 = 12.27$, df = 2, $p = 0.02$). Students whose interest has increased show a greater passing rate than those whose interest remains the same or decreases (increase 85%; same 60%; decrease 59%); however, it is not clear whether for "interest" and "experience" the result is a function of whether students pass or the other way around. These results may also be dependent on the instructor, a factor for which no data is reported. Lastly, in terms of students' views of whether the material will be "useful" in their career, there were no significant differences of this response with passing rate ($\chi^2 = 5.58$, df = 4, $p = 0.23$). This result held even when responses were aggregated by "strongly agree/agree" and "disagree/strongly disagree/don't know" ($\chi^2 = 2.21$, df = 1, $p = 0.14$). Overall, 67% of those surveyed "strongly agreed" or "agreed" that the material would be "useful" in their career with the numbers in the passing group being 71% and 57% in the nonpassing group. Among biology majors, 61% of these students indicated "strongly agree/agree" that the information would be useful to their career, but that still leaves 39% who either don't know or don't think it will be useful. This is certainly a group to which organic instructors need to emphasize the relevance of this topic.

General Chemistry Preparation

At CSUSM, a modified introductory chemistry sequence similar to that reported in reference 11 is used. This one semester course in which native students enroll prior to organic chemistry contains only conceptual ideas in introductory chemistry. These ideas were chosen by the CSUSM Chemistry Faculty to be the minimum content for entering organic chemistry students. Even so, the course is very much like many first-semester general chemistry courses and covered the following topics:

- atomic theory
- chemical bonding
- moles and stoichiometry
- qualitative ideas of acids and bases
- basic chemical reactions (acid–base, precipitation, oxidation–reduction)
- qualitative aspects of energy changes
- qualitative ideas of chemical equilibrium

The only truly quantitative ideas presented in this course are those related to basic stoichiometry, limiting reagents,

Table 5. Passing Rates and Grades Based on Precourse Responses[a]

Group	Pass	No Pass	
C or better			$\chi^2 = 1.23$, df = 1, $p = 0.27$
SEM1	51.9 (55)	48.1 (51)	
SEM2	61.3 (46)	38.7 (29)	
B- or better			$\chi^2 = 0.070$, df = 1, $p = 0.79$
SEM1	26.4 (28)	73.6 (78)	
SEM2	29.3 (22)	70.7 (53)	

	Grades for Passes			
	A	B	C	$\chi^2 = 0.60$, df = 2, $p = 0.74$
SEM1	23.6 (13)	27.3 (15)	49.1 (27)	
SEM2	17.4 (8)	30.4 (14)	52.2 (24)	

[a]Results given by percentage of respondents, absolute numbers of individuals given in parentheses ($N = 161$).

percentage yield, and molarity. Although the idea of chemical equilibrium and the equilibrium constant are introduced, problem solving requiring algebra is not. The structure of the course is very much like a traditional lecture course, although there was a small component of cooperative learning in some semesters (< 20% of class time).

In the CSUSM lower-division curriculum, the two-semester organic chemistry sequence is followed in the fourth semester by the more quantitative ideas of acid–base and oxidation–reduction chemistry as well as thermodynamics and kinetics. Postponing the quantitative aspects of introductory chemistry until the fourth semester gives students time for remediation of deficiencies in math skills. To assure that students do this, there is a Calculus I corequisite for the fourth semester Quantitative Chemistry course.

Given the high percentage of transfer students at CSUSM, the nontraditional introductory chemistry sequence will continue only if the native CSUSM students are not disadvantaged in organic chemistry. Given in Table 5 are data that relate the passing rate with the number of semesters of general chemistry for students completing the precourse survey. Two separate criteria are tested for a successful "pass," C or better and B– or better. Although the passing rate (C or better criterion) for SEM1 over this period is almost 10 percentage points below that for SEM2, the difference is not statistically significant for the current sample ($\chi^2 = 1.23$, df = 1, $p = 0.27$). Further evidence to support this comes from a breakdown of grades among those passing the course. The distribution of grades from both groups, as shown in Table 5, is statistically identical ($\chi^2 = 0.60$, df = 2, $p = 0.74$). If the SEM1 students were disadvantaged, one might expect to see a lower average passing grade than for the SEM2 students. There is no evidence to substantiate this. In addition, using another standard to record a "pass" (B– or better) also shows no significant correlation of passing rate with group; however, the relative passing rates for both groups is such that 40 to 50% of the students do not successfully complete the first semester of organic chemistry at CSUSM either because of failing to achieve a C or better or because they withdrew from the course. This is an issue that is currently being addressed.

It is possible that other factors may explain this lack of a correlation with the number of semesters of general chemistry. For example, in this study there was no evidence that the SEM1 and SEM2 groups were matched in terms of ability or prior content knowledge in chemistry. In addition, it is also possible that the sample is too small to show a statistical correlation. Even given these shortcomings, some speculations as to what this data means will now be made.

One might think that a student successfully completing a two-semester sequence of general chemistry would do better in organic chemistry than a student with only a one-semester background due to a "preparation" or a "weeding out" effect. Within the limitations of this study, however, the data do not seem to indicate that either of these is significant. One possible reason is that the elimination of students during the general chemistry sequence is based extensively upon mathematical ability. Because this skill is not essential for organic chemistry, the more important attributes, such as conceptual reasoning, study skills, or selfdiscipline, may play a larger role in success.

Implications for Teaching Chemistry

So what do the results of this study tell us about teaching and preparation for organic chemistry? The data here seem to imply that student maturity and selfdiscipline might play a very important role. Perhaps the most important thing that instructors can do is to incessantly emphasize to students the necessity of consistently studying the material. Secondly, in terms of general chemistry preparation for organic chemistry, the limited data seem to imply that it may not be important to cover **all** those essential topics in general chemistry, because few may be remembered or even will have been truly understood [22, 23]. The lack of a clear-cut correlation of passing rate with "time since last chemistry course" is contrary to, at least this author's, previous belief.

Because the majority of organic students at many universities are biology majors, there is no evidence to support the idea that these students need to know **all** these important general chemistry topics. Maybe this gives more support to the premise of some of the innovative application-based content being developed for general chemistry, for example ChemConnections [24]. Even sacrificing total content for material that is more relevant to the student may inspire them to actually spend more time studying and learning chemistry.

Conclusion

Few definitive predictors of success rate in the first semester of organic chemistry are shown in this work; however, there is some evidence to indicate that precourse "personal interest," "grade expectations," and "change in interest" after the course show a correlation with passing rate. The "number of hours studying" the material also shows a statistical correlation. Most notable is the fact that the length of time since the general chemistry course was taken does **not** show a significant correlation with passing rate. In addition, the passing rates in first-semester organic chemistry for students who have taken a traditional two-semester general chemistry course and those taking a one-semester course show no statistical difference. These latter two results taken together may imply that, at least for the students studied here, the exact preparation and knowledge of chemistry play less of a role in determining the passing rate in organic chemistry than other factors such as student study habits and motivation. If this is true, then the extra "background" that students gain from a second semester of general chemistry may be important in their overall education, but not necessary when it comes to learning the material in the first semester of organic chemistry. These results are consistent with the idea that the "weeding out"

nature of introductory chemistry may be eliminating "good" students capable of successfully completing more advanced courses. This idea has been discussed by Tobias [25, 26] in her studies of potential structural impediments to the number of students interested in science.

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Supporting Materials. A supporting document containing the pre- and postcourse surveys is available in a Zip file ((http://dx.doi.org/ 10.1333/s00897030675a).

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