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Improving Student Outcomes in Organic Chemistry through Action Research

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Abstract

Action research conducted in an Organic Chemistry classroom at a large, urban, public university has demonstrated that encouraging academic help seeking behavior (a type of self-regulated learning) improves student outcomes especially for students who enter the course with weaker Chemistry backgrounds. Implications for other science courses and for similar student populations (first generation to attend college) will be discussed.

Improving Student Outcomes in Organic Chemistry through Action Research

While many students enter college with the intention of majoring in science or mathematics, a large percentage switches out of these majors during the early college years (Barr, Gonzalez & Wanat, 2008; Eaton, 2004; Seymour & Hewitt, 1997). Moreover, attrition rates of female and ethnic/racial minority students from these disciplines have been disproportionately high relative to that of White males (Barr et al., 2008; Seymour & Hewitt, 1997; Tsui, 2007). Surprisingly, research has indicated that students exiting science and mathematics fields are not necessarily weaker academically; rather, a disproportionately "able" or academically successful group of students leaves these disciplines (Barr et al., 2008; Seymour & Hewitt, 1997).

Various factors are known to contribute to what has been termed the "leaky pipeline" (Rosser, 1997) of science and mathematics undergraduates, including a competitive classroom atmosphere (Tobias, 1990) and poor quality teaching (Seymour & Hewitt, 1997). In some cases, loss of interest and subsequent attrition may be related to negative academic experiences, which may include earning poor grades, negative experiences with TAs/lab instructors, minimal or poor contact with professors (Barr et al., 2008). Of particular interest, however, is the fact that negative experiences with Chemistry courses, especially Organic Chemistry, have played an important role in discouraging students from persisting in premedical studies (Barr et al., 2008; Lovechhio & Dundes, 2002).

A number of reform efforts have arisen in response to the high attrition rates of students in STEM (science, technology, engineering, and mathematics) fields. Two well-known efforts by the National Science Foundation (NSF) are POGIL (Process Oriented Guided Inquiry

Learning) and PLTL (Peer-Led Team Learning) (Gosser & Roth, 1998; Farrell, Moog, & Spencer, 1999). Both POGIL and PLTL focus on changing traditional science classrooms into environments that are more student-centered. POGIL replaces traditional lectures with student-focused, problem solving activities, while PLTL utilizes undergraduate peer tutors to run supplementary problem solving sessions for small groups of students. Both POGIL and PLTL have resulted in significant improvements in student retention and performance in a variety of classroom settings (e.g. public universities, private colleges) and across science disciplines (Gosser, 2011; Eberlein et al., 2008).

Setting

In January 2010, author GH was hired by the Chemistry Department of "Urban University" (UB), a large, public university located in the Northeastern United States. Upon hire as a Lecturer, GH was charged with improving student performance in Organic Chemistry, a course that was notorious for its high withdrawal plus failure rate (approximately 50%).

GH was a skilled instructor with over 20 years of college-level Chemistry teaching experience. In addition to her expertise in Organic Chemistry, GH was trained as a science educator. However, she had not previously taught an Organic Chemistry lecture course and she had spent her entire teaching career working at a small, private, liberal arts college. Therefore, upon arrival at UB, GH immediately attempted to learn about the student population, specifically why UB students had such a difficult time succeeding in Organic Chemistry.

Spring 2010: First Impressions

The Institution

One of the first things that author GH learned was that a number of institutional factors influenced student retention rates in Organic Chemistry. For example, at her previous institution,

the drop (without penalty) date had sometimes been as late as week 10 of the semester, whereas at UB it occurred in week 3. At UB, many students realized that their grades were in jeopardy well past the drop without penalty deadline; as a consequence, many students ended up withdrawing rather than dropping Organic Chemistry.

Additionally, many students remained in Organic Chemistry for financial reasons. In order to maintain a full program and receive financial aid, students would stay in the course past the withdrawal date when clearly they were failing or knew that they could not devote sufficient time to the course due to other responsibilities. As a consequence, many UB students would end up earning grades of "F" rather than being able to drop without penalty (as they would have done at GH's previous institution).

GH also learned that institutional finances were a much bigger factor at her new institution. For example, both POGIL and PLTL had been tested in the Organic Chemistry course at UB, and although preliminary results by Contel (2009) had shown that these methods were effective in improving student outcomes, they were no longer being utilized because of the costs involved. POGIL required limiting lecture class sizes to 50 to 60 students and PLTL required the hiring and training of 8-10 peer tutors per semester.

The Students

During her first semester at UB, GH was assigned to teach two recitation-lab sections of Organic Chemistry I. Each section enrolled approximately 24 students and met for 5 hours per week (1 hour for recitation and 4 hours for lab). Because of the small class sizes and long contact hours, GH had the opportunity to get to know her students quite well. She used the opportunity to gather anecdotal information about students to ascertain what student-related factors impacted course performance.

One of the first things GH noticed was that most of the students were immigrants to the United States. Most of them spoke a first language other than English (e.g. Haitian Creole, Russian, Spanish), and while the majority were of traditional college age, they were unusual in terms of lifestyle (many worked part or full time while maintaining a full course load). In addition, many of the students were clearly afraid of Organic Chemistry, and approximately 60% had attempted the course at least once before. Overall, however, the students seemed highly motivated, serious, and hardworking. They also seemed very respectful and generally did not act demanding or entitled. GH later learned that many students came from poor or working class backgrounds and/or were the first among their family members to attend college.

What Can I Do To Make Things Better?

During her initial months at UB, GH felt overwhelmed. She watched many students struggle and fail, and she did not know how to help them. Then a friend and colleague, who had successfully taught Organic Chemistry at another public university for many years, gave her two helpful suggestions. First, the colleague suggested that GH ask the students what she could do to help them. Second, she suggested that GH use the handing back of the first midterm as an opportunity to meet with students individually to address their performance in the course, their study methods, and to make suggestions for how to improve their learning and grades.

GH implemented her colleague's proactive suggestions. She directly asked students for suggestions for how she could be helpful. One student suggested having an extra problem session each week in addition to the recitation period. GH implemented this suggestion. GH also scheduled appointments with as many students as possible to discuss their midterm exams; in total, she met with 29 of the 44 students. She noticed that some students really seemed to benefit from the meetings. For example, some students engaged with GH in an honest discussion

about their study strategies and how they might be improved or revised to match the problem-solving nature of Organic Chemistry.

After meeting one-on-one with students and holding several extra weekly problem sessions, GH noticed a dramatic improvement in the performance of some students. While some students who had done poorly on the first midterm continued to do poorly, others managed seemingly miraculous improvements. Upon reflection, GH realized that what students who improved seemed to have in common was **help seeking behavior**. Some had come to GH's office to talk about their class performance and walked away with strategies for improvement. Others attended the weekly extra problem sessions where they received individualized attention and feedback when they felt "stuck." It seemed to GH that those who had improved were those who: a) sought help; and b) were successful in receiving the help they needed. Others who did not seek help or for some reason were not successful in receiving the help they needed continued to struggle in the course.

This finding that students who sought help survived and passed was exciting to author GH. She did not view it as a panacea, knowing full well that there were other obstacles that students faced (long commutes, job and family responsibilities, etc.). But she was excited by the possibility that she could do something proactive and concrete to help students succeed.

Summer 2010: Planning For The Fall

The following semester would be GH's first opportunity to put what she had learned to use. For the Fall 2010 semester, GH was assigned to teach the main, large Organic Chemistry I lecture, which enrolled over 200 students and included 9 recitation-laboratory sections. GH dedicated the summer of 2010 to designing the lecture course. She gave much thought to how to chunk and present the course content effectively and also how to assess student learning.

GH devoted time to meeting with the new graduate student recitation/lab instructors to try to improve the pathway by which they could be guided, trained, and kept informed about the course. She also met with the Director of the College's Learning Center and the College's Pre-Health Advisor to form and foster relationships with them and to learn about their past and current efforts to improve student performance.

GH spent a lot of time during the summer designing her website and syllabus such that both of these resources would focus student attention on the variety of help seeking resources available to them when taking the course, including office hours, Learning Center tutors, and a variety of online resources. To educate students further about the course and set a proper tone, GH emailed the incoming class early in the month of July to welcome them. GH hoped to set a positive, non-threatening tone for the course and to let students know, in advance, what to expect and where to find available resources and sources of help.

Fall 2010: Beginning to Study Help Seeking Behavior

A Need for Action Research

It was exciting to begin teaching Organic Chemistry I in Fall 2010. From the start, GH felt that things were heading in the right direction. Students flocked to her office hours and many attended the extra problem sessions that she held before quizzes and exams. But GH began to notice that she would see many of the *same* students at office hours or problem sessions. Thus, while her efforts to create a help-seeking atmosphere led to help seeking in some students, these efforts failed to inspire behavior change in other students.

Author GH wanted to understand who was seeking help and why, who was not seeking help and why, and whether or not help seeking was actually benefiting students in terms of course performance. GH recruited the assistance of colleague and co-author LR, and after

obtaining IRB approval, they embarked on a course of action research. GH designed an online questionnaire, which she administered to students immediately following the return of their first midterm (week seven of the semester). Among other things, the questionnaire inquired about students' help seeking behaviors, perceived need for help, perceived barriers to help seeking, and weekly study time devoted to the course.

Findings

Help seeking and midterm performance. The overall response rate for this voluntary survey was 58% (students at all levels of class performance participated in the survey).
A stepwise multiple regression analysis was conducted to estimate a regression model that best predicted midterm performance among students based on help seeking activities (i.e., the combination of attendance at problem solving sessions and office hours), study time (i.e., number of hours per week spent studying for the course), and perceived need for help in understanding the class material. Prior to conducting the analysis the authors tested various assumptions, including normality of distributions, linear relationship between midterm performance and factors, normality of residuals, and multicollinearity. Each factor was correlated with the dependent variable. Measures of skewness and kurtosis indicated that the dependent variable (i.e., midterm performance) was negatively skewed. Therefore a square root transformation was conducted on midterm performance after the scores were reflected due to the negative skewness.

Results of a stepwise multiple regression analysis revealed that two of the three factors emerged as significant predictors of midterm performance ($F = 10.12$, $p < .001$). With a beta of -.32 ($p < .001$), help seeking emerged as the strongest predictor, accounting for 10.7 percent of the variance in midterm performance. The second significant factor was perceived need for help

(beta = -.23, $p < .05$), accounting for an additional 5.2 percent of the variance in midterm performance. Overall, the model explained approximately 16 percent of the variance ($R = .40$). On the other hand, about 84 percent of the variance in midterm performance was still unaccounted for in this model. Notably, overall study time dropped out as a factor in this stepwise analysis suggesting that it did not make a significant contribution to midterm performance above and beyond the contributions of the other factors.

Extent of help seeking / barriers to help seeking. The Fall 2010 data demonstrated that help seeking was related to midterm exam performance. Our next task was to examine the extent to which help seeking was occurring. Survey data from class respondents (58% of students who completed the first midterm) indicated that the majority of respondents had sought some form of help before the first midterm exam: 58% had attended at least one extra problem session, 52% had attended office hours at least once, 56% had participated in some form of tutoring, and 32% had visited the learning center.

While the percentage of students seeking help was high, it was clear that there were some students who did not seek help at all or who did so infrequently. The survey data provided some explanations for why this was the case. Although the vast majority of respondents indicated that they were comfortable seeking help from their recitation and lecture instructors, 51% of respondents indicated that the times available to obtain help did not match their schedules. Among the schedule constraints of students, 70% indicated that a full course load interfered with seeking help, 61% indicated that family responsibilities interfered, and 46% indicated that work responsibilities interfered.

Discussion

Other possible causes for a lack of help seeking: Although time constraints were important self reported causes of not seeking help, the authors considered whether additional factors might encourage stronger students to seek help and/or discourage weaker students from seeking help. For example, GH observed that students who presented as more self confident seemed more comfortable seeking help while poorly performing students seemed ashamed of their lack of knowledge or afraid that asking questions would bother or annoy the instructor. GH began to suspect that these student behaviors were related, in part, to SES and parents' levels of education. She speculated that students who had grown up in wealthier households might take steps to ensure that their academic needs were met, whereas students from less privileged backgrounds might be accustomed to having to settle for less. It also seemed that some students (perhaps because their parents were college educated) were more savvy about how to be successful in college, whereas other students (perhaps those whose parents had lower levels of education) were not as proactive about getting help when they needed it.

Reports in the help seeking literature are consistent with these observations. Marchand & Skinner (2007) suggested that help seeking may have the net result of being most helpful to those who are least in need of help (the strongest students), a phenomenon they describe as the "rich … become richer".. Research has explored various explanations for the observation that lower achieving students are less likely to seek help. These students may have lower self-efficacy (Ryan & Shin, 2011), they may feel embarrassed to admit their failings (Newman, 1994; Shapiro, 1983), and/or they may be less aware of their need for help (Wood & Wood 1999).

Controlling for prior performance. In the case of GH, the majority of her students reported that timing and logistical issues interfered with obtaining help. It was clear that some rescheduling would have to occur so that resources such as office hours and extra problem

sessions could accommodate a larger number of students. Before planning for future semesters, however, it became apparent that it would also be necessary to control for students' prior aptitude in chemistry. In other words, help seeking did seem to impact students' performance. However, what if it was just the academically strong students who were seeking help? How might the researchers determine whether academic help seeking was truly helping the students who needed it most?

To address this issue, the authors reviewed student transcripts for information about students' letter grades in General Chemistry II, which serves as the pre-requisite course for Organic Chemistry I. The authors then excluded students who took General Chemistry II at institutions other than UB because of the variability in course content and grading standards across academic institutions. The authors subsequently correlated students' General Chemistry II grades with the final numerical grades obtained in Organic Chemistry I in Fall 2010. The simple Pearson Correlation coefficient for this relationship was 0.70 ($p < 0.001$); in other words, approximately 50% of the variability in Organic I grades was directly related to how students performed in their previous class-- General Chemistry II. The authors were quite surprised by this large correlation since there is little overlapping content between General Chemistry II and Organic Chemistry. The authors pondered this finding and concluded that for UB students, General Chemistry II was a good predictor of Organic Chemistry performance because it likely measures *not just* General Chemistry knowledge, but *also* prior overall science background and science study skills.

The authors arrived at this conclusion for several reasons. First, because of high school requirements in NY State, General Chemistry operates as an advanced version of the chemistry course that most state residents take in high school. UB students with strong high school science

backgrounds often anecdotally report that General Chemistry is not difficult for them. By contrast, students with weak high school backgrounds tend to report the opposite. Additionally, students anecdotally report that success in Organic Chemistry is tied to the development of disciplined study and long hours in the library. UB students with strong high school science backgrounds frequently report that they did not need to work hard before they enrolled in Organic Chemistry or that they did not know how to study until they took Organic Chemistry.

Although the authors could not verify their explanations for why General Chemistry II was such a good predictor of Organic I performance, they came to the conclusion that it would indeed serve as a relevant and potentially important control variable. Therefore, in subsequent semesters, the authors used students' General Chemistry II grades to control for prior student aptitude and ability.

Spring 2011: Encouraging More Widespread Help Seeking

How to Increase Student Participation?

GH began the Spring 2011 semester with a new crop of Organic Chemistry I students (initial enrollment was approximately 140), and with a challenge to herself to further encourage and foster help seeking behaviors. She decided to increase the number of problem sessions offered to students. Instead of only holding problem sessions before quizzes and exams, she held two extra problem sessions per week, one during the day during club hour (when classes do not meet) and one on a weeknight in the early evening. She also decided, partly because of her own time constraints, to shorten the problem sessions to one hour in length from two hours as they had been in Fall 2010.

Based on feedback from students from the Fall 2010 semester, GH also recruited peer tutors to assist during the problem sessions. She located a number of former students who were

willing to assist during the problem sessions so that there would always be a minimum of 2-3 people walking around who were available to answer student questions.

In order to quantify the extent of help seeking behavior and to ascertain how it impacted student performance, the co-authors again administered a Likert scaled survey to students after the first midterm. They modified the survey slightly to include a question about students' performance in General Chemistry II (to use as a control) and added a few open ended questions intended to determine why students might not partake of the various help seeking resources available to them. GH also collected her own observational data of student attendance at each of her problem sessions and office hours (i.e., she noted each instance in which a student attended one of these sessions).

Findings

Extent of help seeking. Survey data from the respondents (45% of those who completed the first midterm) indicated that 100% respondents had sought some form of help before the first midterm exam. 63% had attended at least one extra problem session (a 5% increase from the fall), 66% had attended office hours at least once (a 14% increase from the fall), and 35% had visited the learning center at least once (a 3% increase from the fall). Notably, students at all levels of class performance participated in the survey.

Help seeking and midterm performance. Only students who completed General Chemistry II at UB were included in this analysis. A stepwise multiple regression analysis was conducted to estimate a regression model that best predicted midterm performance among students based on five factors: help seeking activities (i.e., attendance at problem solving sessions and office hours), study time (i.e., number of hours per week spent studying for the course), perceived need for help in understanding the class material, and grade in General

Chemistry II. It should be noted that attendance at problem sessions and office hours were separated for this analysis due to GH's restructuring of the course to include many extra problem sessions per week. Prior to conducting the analysis we tested various assumptions, including normality of distributions, linear relationship between midterm performance and factors, normality of residuals, and multicollinearity. The only factor significantly correlated with the dependent variable was General Chemistry II grade; we nonetheless carried each of the variables into the stepwise multiple regression based on theoretical considerations described above. As before, measures of normality indicated that the dependent variable (i.e., midterm performance) was negatively skewed. Therefore a square root transformation was conducted after the variable midterm performance was reflected (due to the negative skewness).

Results of the stepwise multiple regression analysis revealed that only two of the five factors emerged as significant predictors of midterm performance ($F = 10.27$, $p < .001$). With a beta of -.54 ($p < .001$), General Chemistry II grade emerged as the most significant factor, accounting for 25.6 percent of the variance in midterm performance. The second significant factor was attendance at problem sessions (beta = -.27, $p < .05$), accounting for an additional 7.2 percent of the variance in midterm performance. Overall, the model explained approximately 32.8 percent of the variance ($R = .57$), a significant improvement over the Fall 2010 model, which did not include General Chemistry II grades. Notably, overall study time dropped out as a factor in this stepwise analysis as did attendance at office hours and perceived need for help, suggesting that these factors did not make a significant contribution to midterm performance above and beyond the contributions of the other factors. In addition, the authors re-ran the stepwise analysis excluding those students who had scored an A or A+ in General Chemistry II. In this analysis, the only significant factor was attendance at problem sessions ($F = 5.27$, $p <$

.05). The beta value for attendance at problem sessions was -.39, p <.05, accounting for 14.9 percent of the variance in midterm performance.

Help seeking and overall course performance. As mentioned above, during the Spring 2011 semester GH also tracked student attendance at each of her problem sessions and office hours (i.e., she noted each instance in which a student attended one of these sessions and summed them to attain a total "help seeking" score). A stepwise multiple regression analysis was carried out to estimate a regression model that best predicted total course performance (i.e., final class grade) among students based on help seeking activities and grade in General Chemistry II (as this variable proved important in the previous analysis). Prior to conducting the analysis the authors tested various assumptions, including normality of distributions, linear relationship between total course performance and the factors, normality of residuals, and multicollinearity. Both factors were correlated with the dependent variable. Measures of skewness and kurtosis indicated that the dependent variable (i.e., total course performance) was negatively skewed. Therefore a square root transformation was conducted after the variable total course performance was reflected.

Results of the stepwise multiple regression analysis revealed that both factors were significant predictors of total course performance (F = 44.12, p < .001). With a beta of -.59 (p < .001), General Chemistry II grade emerged as the most significant factor, accounting for 38.2 percent of the variance in total course performance. The second significant factor was help seeking behavior (beta = -.30, p < .001), accounting for an additional 8.7 percent of the variance in total course performance. Overall, the model explained approximately 46.9 percent of the variance (R = .69). Notably, when the authors re-ran the analysis without the students who scored an A or A+ in General Chemistry II, both factors continued to be significant (F = 14.1, p < .001).

With a beta of -.40 ($p < .001$), help seeking behavior now emerged as the most significant factor, accounting for 17.6 percent of the variance in total course performance. The second significant factor, General Chemistry II grade (beta = -.33, $p < .01$), accounted for an additional 11.1 percent of the variance in total course performance. Overall, this model explained approximately 28.7 percent of the variance ($R = .54$).

Discussion

Results obtained in Spring 2011 were encouraging in terms of their consistency with Fall 2010 results but also the demonstrated improvement in help seeking. Specifically, the restructuring and rescheduling of problem sessions resulted in greater student attendance. Additionally, help seeking behavior was able to explain a sizeable portion (7-9%) of the variability in student performance even when prior performance in General Chemistry II was taken into account. Most interesting from an academic perspective was the finding that help seeking behaviors were actually benefitting the weaker students—those presumably most in need of some form of assistance. When the strongest General Chemistry II performers were excluded from the analyses, the explanatory power of help seeking behavior increased substantially.

Summer 2011: The Self-Regulated Learning Literature

Feeling optimistic that the data did indeed demonstrate improved student performance with help seeking behavior, GH spent some time during the summer of 2011 reviewing the literature on self-regulated learning and academic help seeking. Self-regulated learning is a sociocognitive theory that argues that individuals monitor their own learning processes, employ strategies to meet their goals, and modify behaviors in response to feedback (Zimmerman, 1990). Help seeking is one of a number of self-regulated learning strategies postulated by Zimmerman and others (see Newman, 1994; Zimmerman & Martinez-Pons, 1986).

In reviewing the literature, GH found that while several articles discussed self-regulated learning and/or academic help seeking among college students, relatively few examined these behaviors in science or mathematics contexts. For example, a study by Dibenedetto and Bembenutty (2011) demonstrated a positive association between the use of self-regulated learning strategies and science achievement. A study by Nandagopal (2006) found a relationship between the frequency of use of self-regulated learning strategies and science achievement; specifically, self-regulated learning strategies accounted for almost as much variance in academic performance as prior GPA. An intervention study involving remedial math students at a technical college (Zimmerman, Moylan, Hudesman, White, & Flugman, 2011) revealed that training students in self-regulated learning strategies (specifically training them to review and correct their own quizzes) resulted in treatment students outperforming control students by 25% on a national "gateway" examination.

With regard to help seeking behaviors among chemistry students, Karabenick (2003) found that General and Organic Chemistry students who were strategic help seekers performed better than students who avoided seeking help. Szu and colleagues (2011) found that higher achieving Organic Chemistry students engaged in help seeking behavior earlier in the semester than lower achieving students. They also found that although student performance in Organic Chemistry was strongly correlated with prior GPA, study behaviors and concept mapping made a much larger contribution to course performance than prior GPA.

Spring 2012: Continuing Our Efforts

The next opportunity to corroborate the findings from the previous semesters occurred the following Spring when GH was again assigned to teach the large Organic I lecture class (enrollment was approximately 140 students). Once again, the co-authors administered their

Likert scaled survey to students immediately after the first midterm and GH also collected observational data of student attendance at each of her problem sessions and office hours.

Findings

The overall response rate for this voluntary survey was 44%. As before, students at all levels of class performance participated in the survey and only students who completed General Chemistry II at UB were included in the analysis. A stepwise multiple regression analysis was conducted to estimate a regression model that best predicted midterm performance based on five factors: help seeking activities (i.e., attendance at problem solving sessions and office hours), study time (i.e., number of hours per week spent studying for the course), perceived need for help in understanding the class material, and grade in General Chemistry II. Prior to conducting the analysis the authors tested various assumptions, including normality of distributions, linear relationship between midterm performance and factors, normality of residuals, and multicollinearity. The only factors significantly correlated with the dependent variable were General Chemistry II grade and attendance at problem sessions; as before, however, the authors carried each of the five variables into the stepwise multiple regression based on theoretical considerations. Measures of skewness and kurtosis indicated that the dependent variable (i.e., midterm performance) was negatively skewed. Therefore a square root transformation was conducted after the variable midterm performance was reflected.

Results of the stepwise multiple regression analysis revealed that only two factors were significant predictors of total course performance ($F = 8.75$, $p < .01$). With a beta of -.39 ($p < .05$), attendance at problem sessions emerged as the most significant factor, accounting for 15.8 percent of the variance in total course performance. The second significant factor was General Chemistry II grade (beta = -.33, $p < .05$), accounting for an additional 10.5 percent of the

variance in total course performance. Overall, the model explained approximately 26.3 percent of the variance (R = .51). Notably, when we re-ran the analysis without the students who scored an A or A+ in General Chemistry II, both factors continued to be significant (F = 6.77, p < .01). With a beta of -.43 (p < .01), help seeking behavior (i.e., attendance at problem sessions) emerged as the most significant factor, accounting for 17.5 percent of the variance in total course performance. The second significant factor, General Chemistry II grade (beta = -.34, p < .05), accounted for an additional 11.6 percent of the variance in total course performance. Overall, the model explained approximately 29.1 percent of the variance (R = .54).

Discussion

At present (April 2012), the authors do not have the final course grades from the Spring 2012 semester; therefore, they are unable to determine the predictive value of help seeking for overall course performance. However, the Spring 2012 midterm survey results were generally consistent with the results obtained in Fall 2010 and Spring 2011 corroborating the finding that help seeking behavior (especially attendance at problem sessions) does indeed significantly improve student performance in Organic Chemistry I.

Significance

UB has a very diverse population of students. Of the approximately 11,000 undergraduate UB students, half are minority, with almost 40% from groups underrepresented in STEM disciplines. Approximately 60% of UB undergraduates are women, 60% come from households with annual incomes of less than $30,000, and many are immigrants and first-generation college students. Overall, our results indicate that when a diverse group of undergraduate students participates in help seeking, their performance in a challenging, gatekeeping course like Organic Chemistry can be improved significantly. These results have important implications for similar

populations of students enrolled in all types of introductory science courses both at UB and elsewhere.

Limitations

The study was limited in terms of the types of data available to the researchers. We did not have demographic data (e.g. gender, race/ethnicity, parents' level of education), which could have improved the explanatory power of our models. This study also excluded transfer students, which limited the generalizability and potential impact of our findings since many UB students are transfer students. Additionally, transfer students who take General Chemistry II outside of UB have particular trouble succeeding in Organic Chemistry I when they arrive at UB (Kobrak, 2006). In addition, our survey data only achieved a response rate of about 50%. However, students at all levels of performance were represented among survey respondents and our observational data included all students.

Future Work

When studying large classes, one is forced to examine student performance from somewhat of a distance and it is easy to lose sight of individual students. In other words, despite the promising findings described above, every semester GH observes Organic Chemistry students who "don't make it," who fail or withdraw. Additionally, every semester GH observes students who exhibit worrisome behaviors, which seem to be the antithesis of what self-regulated learning should look like. For example, GH observes students who avoid seeking help, who avoid obtaining feedback (e.g., who fail to retrieve their exams and quizzes), who avoid meeting with the instructor, and who even avoid attending class (where the instructor provides suggestions about what to focus on and how to study).

GH has learned from her students that when parents are less familiar with the American educational process (e.g., immigrants, not college educated), a message sometimes conveyed is that students "just need to study harder." Some students have communicated to GH that their parents lack an appreciation or true understanding of what it takes to succeed in pre-medical courses, and that sometimes it is not about "studying harder," but rather it is about "studying smarter." This may involve being more strategic about one's organizational skills and study habits. Newman (2000), for example, showed that socialization of students by parents and teachers influences help seeking behavior. Further, Zimmerman (1990) pointed out that weaker students, who are not self-regulated, talk about working harder rather than talking about the strategies they will utilize to try to improve.

A related issue has to do with the beliefs that students hold about their own intelligence (Dweck & Leggett, 1988). GH has noticed that some students who are doing poorly in Organic Chemistry seem ashamed and self blaming, believing that their failure is due to a lack of ability (entity beliefs about intelligence), rather than due to a lack of strong science background (incremental beliefs about intelligence).

The degree to which students' self-regulated behaviors are learned from parents and/or are influenced by the beliefs students hold about their own intelligence and self-efficacy, remains to be determined. Other important issues that warrant clarification include how instructors can best reach the non self-regulating students, how instructors can convince students of the benefits of help seeking, and how instructors can train students to adopt behaviors that stronger students seem to already demonstrate (e.g. picking up and reviewing graded materials, making lists of questions they need help with, and creating flash cards). Hopefully the authors can draw some conclusions through future research while benefitting students through their efforts.

Conclusions

This study explored the potential impact upon performance in Organic Chemistry I of student participation in academic help seeking activities such as attendance at problem sessions and office hours. The authors found that the frequency of engaging in help seeking significantly explained the variability in student performance. Additionally, we found that help seeking was particularly beneficial to weaker students whose General Chemistry II grades predicted poor outcomes for Organic Chemistry I. This study has important implications for others who teach introductory science courses, especially for those who teach underrepresented students, because it supports the findings of Zimmerman et al. (2011) that encouraging students to engage in self-regulated learning behaviors can especially benefit at-risk students.

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