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RESEARCH

Changes in Pharmacy Students' Self-Reported Learning Strategies Across a Four-Year Doctor of Pharmacy Program

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Objective. Few studies describe changes in students' class preparation, note-taking, and examination preparation over the course of professional school. This study aims to describe the use of these learning and study strategies by pharmacy students and to analyze changes during their education.

Methods. We performed a prospective, observational cohort study of students at a single US pharmacy school from 2016-2019. Students completed an online survey on learning and study strategies at the beginning of each school year. Quantitative results were analyzed by level in pharmacy school during which the survey was completed as the primary predictor. Open-ended responses were thematically analyzed using an inductive approach.

Results. We observed significant changes in strategies, including an increased use of audiovisual materials for course preparation, preference for electronic over manual notetaking, increasing use of lecture capture viewing, and increased use of peer materials in studying. Changes were generally largest between students' first (P1) and second (P2) years in pharmacy school, representing adjustments in student behaviors during the P1 year. In some cases, changes from the surveys in the P1 to P2 years were followed by a gradual return toward P1 survey levels. Three themes described students' comments: students' preferences shaped their learning strategies, their experiences guided changes in learning strategies, and they used additional strategies beyond those included in the survey items.

Conclusions. Significant changes in pharmacy student study strategies occurred over the course of their education. This may represent an opportunity to promote use of more effective approaches for long-term learning.

Keywords: pharmacy students, study skills, student development, study environment

INTRODUCTION

The transition to pharmacy school may require students to adjust their prior learning strategies. While prepharmacy education typically emphasizes knowledge attainment, pharmacy programs focus on knowledge in addition to the "… skills, abilities, behaviors, and attitudes necessary …" for pharmacy professionals.[1] Many pharmacy schools also employ an active learning approach that necessitates student engagement in their learning, which may differ from prior instructional methods.[2]

How students participate in learning can significantly affect their academic success. Inefficient study skills contribute to poor academic performance among students, including those enrolled in health professions programs.[3-5] Examples of effective study skills include knowledge retrieval, spaced studying, interspersing topics while studying, elaboration, generating answers, reflective learning, and evaluating one's learning.[6] There are also specific strategies that maximize classroom learning. For example, some studies report that taking notes electronically, rather than by hand, negatively impacts students' academic performance.[7,8] Additionally, well-designed class preparation materials for an active learning classroom can promote self-directed learning, and completion of these preparatory materials has been associated with academic success.[9,10]

The University of California San Francisco (UCSF) School of Pharmacy emphasizes application-based learning using a scientific mindset. Students are expected to think critically and actively participate in their learning. Instructors at UCSF have anecdotally observed that some individual poor performers require coaching on more effective learning and study strategies. However, at the time this study was conducted, little was known about how cohorts of pharmacy students approach learning and

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studying over the course of their schooling. Therefore, this study aimed to describe the relative use of different learning and study strategies by pharmacy students and to analyze changes in use over four years at one institution.

METHODS

This is a prospective, observational study of UCSF pharmacy students from 2016-2019. The UCSF institutional review board certified the study as exempt from review. During the study, the UCSF Doctor of Pharmacy (PharmD) curriculum had a traditional, progressive structure with basic and clinical sciences typically taught as separate courses. Expectations for completion of prework varied across courses. Recorded videos or readings were more common preparatory methods among clinical science courses. Team-based learning was not a significant component of the curriculum during this time, and grading followed the A-F scale.

All UCSF PharmD students were invited to complete an electronic survey (Qualtrics Inc, Provo, UT) designed by the study investigators to characterize students' self-reported learning and study strategies. The survey was delivered to first- through third-year pharmacy (P1-P3) students prior to the start of each didactic year during an in-person orientation. Fourth-year (P4) advanced pharmacy practice experience students were invited during the same time period. All students, except for P1 students, were asked to reflect on their study habits in pharmacy school over the last year; P1 students were asked to respond based on their previous collegiate experience. Each participant was assigned a numeric identification to track responses over time. One reminder email was sent one week after initial survey distribution to students who did not initially respond to the survey. The survey was not formally validated, but an earlier version was administered to a group of students not included in this study, and the results and feedback were used to develop this survey.

The survey consisted of 37 questions categorized into six domains: self-assessment of grit (domain 1), completion of lecture preparatory activities (domain 2), in-class note-taking (domain 3), examination preparatory activities (domain 4), study time allocation (domain 5), and other approaches to learning or the learning environment (domain 6). Results from domain 1 have been published separately.[11] This study reports findings from domains 2-6. For P1 students, administration of the survey was followed by an hour-long session on effective study strategies. For P2 and P3 students, a 15-minute lesson on study strategies followed survey administration. Students could also proactively seek out support on study strategies from student services.

For questions about lecture preparatory activities (domain 2) and in-class note-taking (domain 3), students were asked to select a frequency (usually [>75%], often [51%-75%], sometimes [26%-50%], or rarely [<25%]) representing how often they performed each of six specified preparatory activities or three note-taking strategies. For questions on frequency of examination study strategies (domain 4), students could select "not at all," "only just prior to exam," or "regularly during the quarter." Domain 5 asked students to allocate a percentage of time for three study strategies (rereading or reviewing materials, creating summaries, and self-testing) for their hardest examination of the quarter, which was bounded at 100%. Students were also invited to provide free responses regarding anything else they wanted to share about their learning strategies or environment (domain 6).

Responses were described and analyzed by year in pharmacy school (also referred to as *survey year*) when they responded to the survey. The term *cohort* describes the anticipated year of graduation for the student based on their enrollment (eg, class of 2021). For domains 2, 3, and 5, we reported and plotted the mean of the category response items as a summary of student responses. For domain 4, we reported the percentage of responses in each response category. We then used mixed-effects regression models (linear regression for domains 2, 3, and 5 and ordinal regression for domain 4), clustered on student to account for repeated measures, to evaluate changes in responses over the study.[12] The primary analyses included all student responses across all cohorts. Responses stratified by cohort and for the cohort with four years of data were inspected to determine whether there were significant departures from the trends of all student responses. Statistical significance was defined as $p<.05$. Statistical analyses were performed with Stata/SE version 17.0 (StataCorp LLC).

Two investigators analyzed the free-response item in domain 6 from one cohort with four years of data (class of 2020) using thematic analysis.[13] An inductive approach was used due to the broad nature of the question. The two investigators first independently coded all responses using Microsoft Excel and then met to discuss the codes and review code applications. These investigators then created a codebook, which was used to recode responses. After the second iteration of coding, discrepant codes were reviewed and resolved by a third investigator. Intercoder reliability was calculated by percentage agreement.[14] Codes were categorized into subthemes and themes by the two coders and further refined in discussion with the other study investigators.

RESULTS

We received 1378 responses out of 1596 surveys sent (response rate, 86.3%). Data were obtained across four years

for one cohort, three years for two cohorts, two years for one cohort, and one year for one cohort, for a total of thirteen cohort-years of data. Response rates were high across P1 through P3 students (91.8%-96.4%) and were lower for P4 students (68.5%) (Table 1). Response rates were generally similar between graduation cohorts within a survey year. A total of 578 different students were represented in the survey; the mean number of responses per student over the study period was 2.4 (range, 1-4). A subgroup of 76 students from the class of 2020 provided complete responses to all four years of the survey. Across the five graduation cohorts, 70% of respondents were female, 75% identified their race/ethnicity as Asian/Asian American, 98% had completed a four-year undergraduate degree, and their mean age upon enrollment in pharmacy school was 22.9 years.

The most common activity that P1 students reported completing as preparation for class (domain 2) was required quizzes, followed by required audiovisuals, required readings, suggested quizzes, suggested audiovisuals, and suggested readings, in that order (Figure 1). The general pattern of changes in these activities was a reduction in frequency of activity from P1 to P2 surveys, followed by an increase from the P2 to P3 and P3 to P4 surveys. These changes were significant for required audiovisuals, required readings, suggested audiovisuals, and suggested readings when comparing P1 students' responses to later years (Figure 1). A composite score consisting of the sum of the activity ratings for the six activities had a baseline mean of 23.4 (out of 30 possible) during the P1 survey; this showed significant decreases in the P2 and P3 surveys, but the difference with the P4 survey was not significant.

Table 1. Learning Strategy Survey Response Rate by Pharmacy School Survey Year and Graduation Cohort

Professional year, % responding (No./Total)	Graduation cohort, % responding (No./Total)
P1: 96.4 (244/253)	2020: 95.2 (120/126)
	2021: 97.6 (124/127)
P2: 95.1 (352/370)	2019: 92.8 (116/125)
	2020: 95.0 (114/120)
	2021: 97.6 (122/125)
P3: 91.8 (455/493)	2018: 82.4 (108/131)
	2019: 93.9 (109/116)
	2020: 93.3 (113/121)
	2021: 97.6 (123/125)
P4: 68.5 (329/480)	2017: 68.9 (82/119)
	2018: 71.3 (87/122)
	2019: 62.3 (71/117)
	2020: 72.9 (89/122)
All: 86.3 (1378/1596)	NA

Abbreviations: P1=first year of pharmacy school; P2=second year of pharmacy school; P3=third year of pharmacy school; P4=fourth year of pharmacy school; NA=not applicable.

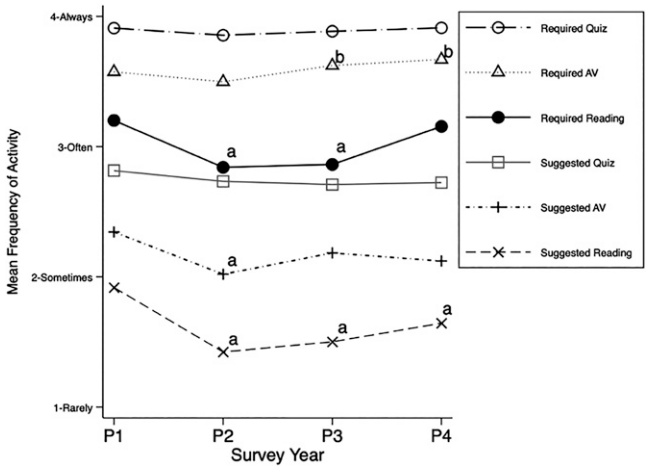

Figure 1. Frequency of lecture preparation activities by survey year (Domain 2).

Abbreviations: P1=first year of pharmacy school; P2=second year of pharmacy school; P3=third year of pharmacy school; P4=fourth year of pharmacy school.

[a]=$p<.05$ for comparison to P1 survey year in mixed-effects regression model.

[b]=$p<.01$ for comparison to P1 survey year in mixed-effects regression model.

Effects regression model.

The frequency of electronic note-taking (domain 3) increased significantly from the P1 to P2 surveys and remained high in the P3 and P4 surveys, while the frequency of manual note-taking decreased from P1 to P2 and remained low (Figure 2). The frequency of not taking notes in class was low but increased in a slight and significant manner over the study period (Figure 2).

Table 2 describes the results from domain 4 questions about the frequency and timing of study strategies (eg, regularly during quarter, just prior to exam, not at all). More than 40% of P1 students reported reading the required readings, reviewing their notes, viewing lecture captures, creating study guides, and studying in groups regularly throughout the quarter to prepare for examinations. There were no significant changes in the distribution of responses over survey years for reviewing a student's own notes and creating study guides. Compared to the P1 survey year, students in the P2 and P3 survey years were less likely to report doing required reading as part of examination studying, although this decrease reversed in the P4 survey. Lecture capture use increased from the P1 to P2 survey years and remained significantly higher during the remaining years. Study group participation was flat across the first three years of the curriculum but dropped significantly by the

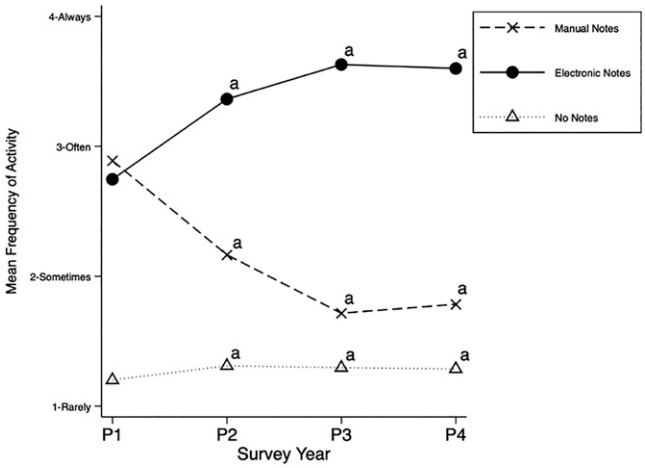

Figure 2. Frequency of in-class notetaking activities by survey year (Domain 3).

Abbreviations: P1=first year of pharmacy school; P2=second year of pharmacy school; P3=third year of pharmacy school; P4=fourth year of pharmacy school.

[a]=$p<.05$ for comparison to P1 survey year in mixed-effects regression model.

[b]=$p<.01$ for comparison to P1 survey year in mixed-effects regression model.

Effects regression model.

P4 survey. Strategies that students frequently reported engaging in near examinations included taking official (instructor-provided) or unofficial practice exams, with a general shift toward a greater proportion of students taking these just before the examination in later pharmacy school years. There were significant increases in reviewing peer study guides and notes as students reached later years in pharmacy school, especially when used near exams.

The amount of time students dedicated to study strategies (domain 5) changed during their pharmacy school progression (Figure 3). At the start of their P1 year, students reported allocating a mean (SD) of 35.3% (20.7%) of their time creating summaries of course material, 38.4% (19.7%) of their time rereading or reviewing course material, and 26.2% (14.7%) of their time completing practice questions/exams. After the P1 year, the amount of time spent rereading or reviewing materials decreased significantly and then rebounded to a similar level by the P4 year ($p=.009$ for P2 to P1 comparison, $p=.33$ for P4 to P1 comparison). The amount of time students spent on practice questions/exams followed a near-inverse pattern, increasing significantly in the P2 survey ($p<.001$ for P2 vs P1) and decreasing to baseline levels by the P4 survey. Time spent creating summaries of materials did not seem to change as students progressed through pharmacy school.

To determine whether observed patterns were similar between cohorts, we also examined graphical plots of the results from each of domains 2-5 separated by cohort.

Table 2. Pharmacy Student Reported Use of Examination Study Strategies Regularly, Just Before Examination, or Not at All[a]

Category of strategy use	P1 category responses, %			P2 category responses, % (P2 vs P1)				P3 category responses, % (P3 vs P1)				P4 category responses, % (P4 vs P1)			
Timing of use	R	B	N	R	B	N	*P* value	R	B	N	*P* value	R	B	N	*P* value
Required readings	77.1	19.3	3.7	70.9	22.2	6.8	.03	71.3	22.1	6.6	.03	79.6	17.3	3.0	.56
Review own notes	65.9	32.8	1.2	72.1	26.8	1.1	.17	65.6	33.1	1.1	.59	62.0	37.1	0.9	.12
View lecture captures	61.1	26.2	12.7	68.9	17.9	13.1	.04	74.6	15.9	9.5	<.01	70.5	16.4	13.1	.02
Create own study guides	52.9	40.2	6.9	54.4	32.2	13.4	.48	57.6	29.4	13.0	.62	55.0	30.4	14.6	.25
Study in group with peers	40.2	38.5	21.3	42.5	38.5	19.1	.65	44.6	35.3	20.1	.34	32.8	35.6	31.6	<.01
Take official practice exams	34.8	64.8	0.4	30.5	69.5	0.0	.42	26.5	73.5	0.0	.03	19.8	79.9	.3	<0.01
Take unofficial practice exams	26.2	59.4	14.3	24.2	72.1	3.7	.05	20.5	65.6	13.9	.19	14.9	66.6	18.5	<0.01
Review study guides created by peers	22.5	54.5	22.9	32.2	59.5	8.3	<.01	34.2	57.2	8.6	<.01	24.5	61.7	13.7	0.02
Read suggested reading	22.5	34.0	43.4	12.5	27.9	59.5	<.01	14.8	26.5	58.7	<.01	13.4	31.6	55.0	.05
Review notes taken by peers	16.8	41.8	41.4	24.5	54.1	21.4	<.01	22.3	50.8	26.9	<.01	17.6	50.8	31.6	.5

Abbreviations: P1=first year of pharmacy school; P2=second year of pharmacy school; P3=third year of pharmacy school; P4=fourth year of pharmacy school; R=regularly during quarter; B=just before examination; N=not at all.

[a] Comparisons between survey years by mixed-effects ordinal logistic regression model clustered on student.

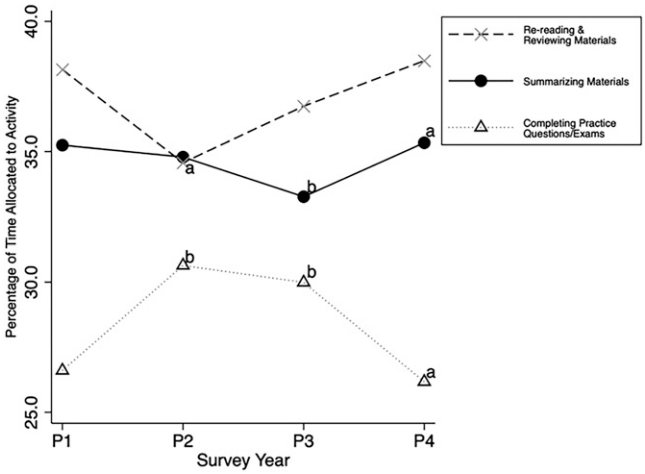

Figure 3. Percentage of time allocated to exam preparation activities (Domain 5).

Abbreviations: P1=first year of pharmacy school; P2=second year of pharmacy school; P3=third year of pharmacy school; P4=fourth year of pharmacy school.

[a]=$p<.05$ for comparison to P1 survey year in mixed-effects regression model (marker at P2 time point is for rereading & reviewing materials).

[b]=$p<.01$ for comparison to P1 survey year in mixed-effects regression model.

Patterns of changes from one study year to another were generally consistent in magnitude and direction across each of the cohorts, including when comparing the cohort with four years of responses to cohorts with two or three years of responses (data available on request). A subanalysis was performed for the 76 students who completed all four surveys. The direction and magnitude of the changes were consistent with effects observed in the primary analyses, although some changes were not significant given the smaller sample size (data available on request).

Under domain 6, 133 comments (response rate, 31%) were analyzed from the class of 2020. Twenty codes (intercoder reliability, 96.4%) were categorized into three themes: Students' preferences shaped their learning strategies, students' experiences guided changes in learning strategies, and students described additional strategies beyond those in the survey (Table 3). The first theme included several subthemes: individual or group studying, application or memorization strategies, learning styles, environmental factors, and curricular factors. In the second theme, students described changes in their strategies based on experiences. This included changes to application or memorization strategies as well as adjustments to individual or group strategies. Additional learning strategies outside of the survey were characterized in the third theme. These included reviewing information through office hours and review sessions and reinforcing learning via teaching experiences and experiential education.

DISCUSSION

In this longitudinal study spanning thirteen cohort-years, we observed several changes in self-reported study and examination preparation strategies among pharmacy students during their education. Students reported an increased use of audiovisual materials for course preparation, preference for electronic over manual notetaking, increasing use of lecture capture viewing as a study strategy, and increased use of peer materials in studying for examinations. Changes tended to be most dramatic between the P1 and P2 survey years; notably, since the survey was administered at the beginning of each academic year, this represents changes in student behaviors during their P1 year. In some cases, large changes from P1 to P2 survey years were followed by a gradual return toward P1 survey levels over the next two years; this was particularly notable for readings in preparation for lectures and examinations.

Since this study began, two publications have characterized pharmacy students' study strategies by cohort and time.[15,16] Persky and Hudson conducted a cross-sectional survey of pharmacy students (P1-P4) to identify study strategies and differences by cohort. The primary study strategy was rereading texts or rewatching videos. P1 students mentioned using more effective study strategies compared to students more advanced in the curriculum. Overall, respondents were more likely to study just prior to the examination rather than spacing out their studying. Persky later conducted a longitudinal study of learning strategies for one cohort of pharmacy students during their schooling.[16] Like the prior study, students reported rereading and rewatching as the most common learning strategy, which did not change significantly over time. In our study, participants also reported studying required readings and viewing videos at high rates across all cohorts, and these study strategies were typically reported as being performed regularly rather than just before an exam. Persky observed a significant decrease in more effective study strategies as students progressed. The author hypothesized these changes reflected a need to "balance academic performance with efficiency," which may be supported by students studying closer to the test in later years. In our study, student time allocated to completing practice questions/exams, which is generally considered to be a more effective study strategy, increased early in the curriculum but then fell back toward baseline levels later in the curriculum, and the proportion of students who used this strategy just before the examination (vs regularly) increased over time. Variability between studies could be attributed to different populations studied, surveys used, response rates, and composition of curricula.

Although our results demonstrated some trends toward more effective study and examination preparation strategies

Table 3. Analysis of Themes, Subthemes, Codes, and Illustrative Quotes From Free Responses to Survey Prompt Regarding Study Strategies (Domain 6)

Theme	Subtheme	Codes	No.	Illustrative quotes
Students' preferences shaped their learning strategies	Individual or group studying	Individual	14	"I like to talk out loud when I study. This is why I prefer studying by myself"
		Group	28	"I love participating in study groups and help tutor friends about the material"
		Both individual and group	14	"I like to review my notes and lectures and do the pre assignments on my own and then regularly study in groups before the exam"
	Application or memorization strategies	Application	37	"Would like more practical applications or examples or simulations of what we learn in textbooks to real life"
		Memorization	18	"I tend to rewrite and summarize my notes … "
		Both application and memorization	6	" … I always make study guides and do practice exams. Then for extremely difficult concepts, I'll say it out loud and write it by hand … "
	Learning styles	Visual	5	"It's sometimes difficult for me to understand lectures that are only spoken and have no visuals..."
		Auditory	6	" … I would relisten to lectures … "
		Linguistic	35	"My main method of studying is re-reading and re-writing class readings and lecture notes"
		Kinesthetic	1	"I'm a kinesthetic learner, so if a course had a laboratory component, I found it was easier to retain information"
	Environmental factors	Timing	1	"Learning most effectively happens in the morning. The afternoon and evening are more difficult to learn..."
		Location	2	"I study in any ambient setting during the course, but study in quiet i.e., library before the exam"
	Curricular factors	Class	3	"My study habits depend primarily on the class I'm taking"
		Exams	1	" … the way I study definitely changes when I have one exam that week compared to if I had three exams"
Additional learning strategies not mentioned on the survey	Review	Office hours	2	" … going to office hours with the TA or professor."
		Review session	1	"Attending course midterm/final review sessions led by professor or TA"
	Reinforce	Teaching	6	"I also teach to help me solidify concepts"
		Experiential education/ Work	1	"I like to ask pharmacists that I work with about some of the practice cases, and see if they can help me reason through what they think and what they would do … "
Students' experiences guided changes in learning strategies	NA	Changes to application or memorization strategies	2	" … incorporate a lot more active learning, less re-visiting material, and consistent testing for long term retention … .after seeing what Advanced Pharmacy Practice Experience students were expected to apply..."
	NA	Changes to individual or group strategies	4	"I learned that my study style is more of an independent-based approach initially, then it gradually transitions into group-based discussions"

Abbreviations: TA=teaching assistant; NA=not applicable.

over time, students still reported rereading/rewatching materials at a higher rate than application-based strategies. Kebaetse and colleagues conducted a review of interventions for learning challenges that included different types of foci (eg, knowledge, professional skills), interventions (eg, proactive, reactive), strategies (eg, faculty, peer led), and durations (eg, weeks, months), with a majority demonstrating positive outcomes.[17] Exploring these interventions may lead to more consistent adoption of effective study strategies among our students.

We also noted a significant trend toward increased adoption of electronic notes and reduced use of manual notes among participants in this study over time. Stacy and Cain described several benefits (eg, speed, legibility) and drawbacks (eg, computer distractions, efficacy) with electronic notetaking. They also mentioned that some of these disadvantages may be overcome through the use of tablet computers.[18] Additional studies on the use of tablet computers for notetaking versus handwritten notes and their associations with academic outcomes would be useful to advise students on ideal notetaking mediums.

Students' comments under domain 6 highlighted preferences that shaped learning strategies. Some of these are rooted in evidence-based literature. Group studying promotes learning through collaboration[19] and application-based strategies lead to deeper learning.[6] However, students' use of learning styles to guide their strategies is controversial and not consistently supported by the literature.[20] Though we did provide students with a brief lecture on effective study strategies, these findings suggest that students in our study would benefit from additional guidance on the limitations of adopting the learning style frame to guide their study habits.

Strengths of this study include its longitudinal nature over four years, large number of responses, and high response rates. Inclusion of multiple cohorts of students allowed us to observe generally consistent effects among consecutive cohorts, suggesting effects are not confined to particular groups of students. Analysis of free-response data allowed us to explore student justifications for their approaches and capture strategies outside the survey items. A potential limitation of the study is reliance on student self-reports, which may lead to overreporting of responses perceived as desirable; however, use of experience sampling or diary methods to more accurately measure behaviors was outside of the scope of the study. While not designed as an interventional study, it is possible that the presentation given to P1 students on effective study strategies influenced strategy use or perception of desirable responses, since some changes reflected recommended study strategies. We examined frequency and distribution strategies but did not determine total study hours or associations of strategies to academic outcomes. We did not link participant responses to individual demographic data, so we cannot discuss potential relationships between demographic variables and study behaviors. Although our overall response rate was high, fewer P4 students responded, leading to potential nonresponse bias. While many of the observed effects were significant, the absolute magnitude in some cases was relatively small (eg, mean changes of 5% for study strategies). Finally, this was a single-center study that may not be generalizable to other programs with different curricular structures, learning approaches, or student populations.

CONCLUSION

We demonstrated several significant changes in UCSF pharmacy students' self-reported learning strategies over the course of their education. The largest changes typically occurred over the first professional year. Many of the changes involved increased adoption of technology, including use of electronic notes, review of audiovisual materials, and review of lecture captures. Further research in this area would ideally be conducted across multiple schools and curricular structures, should test the association of these strategies with demographics and academic performance, and explore student motivations for changing strategies over time.

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