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Experiences in Teaching and Learning

A unique degree program for pre-pharmacy education: An undergraduate degree in pharmaceutical sciences

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ABSTRACT

Background and purpose: Within the coming decade, the demand for well-trained pharmacists is expected to only increase, especially with the aging of the United States (US) population.

Educational activity and setting: To help fill this growing demand, the University of California, Irvine (UCI) aims to offer a unique pre-pharmacy degree program and has developed a Bachelor of Science (BS) degree in Pharmaceutical Sciences to help achieve this goal. In this commentary, we share our experience with our curriculum and highlight its features in an effort to encourage other institutions to enhance the learning experience of their pre-pharmacy students.

Findings: The efforts of the UCI Department of Pharmaceutical Sciences has resulted in UCI being consistently ranked as one of the top feeder institutions by the Pharmacy College Application Service (PharmCAS) in recent years.

Discussion and summary: The UCI Pharmaceutical Sciences Bachelor of Science offers a unique pre-pharmacy educational experience in an effort to better prepare undergraduates for the rigors of the doctorate of pharmacy curriculum.

Background and purpose

The demand for pharmacists to provide direct patient care is expected to only increase within the foreseeable future. This is mainly because of two contributing factors: the increase in the United States (US) average life expectancy from 75.3 years in 1990 to 78.8 years in 2012 and the increased prevalence of chronic diseases (living longer, but sicker), propelling the ever-increasing demand for prescription drugs.^{1–3} Indeed, from 1990 to 2010, the number of dispensed prescriptions for drugs has almost *doubled* (from 1.9 to 3.7 billion).⁴ Consequently, these factors have generated a “perfect storm,” as the growing demand for prescriptions further augments the national pharmacist shortage, beginning in the late 1990s, fueling the need for new pharmacy schools.⁵ In California alone, the number of pharmacy schools has increased more than three-fold since 1999.⁶ Yet, even with these additional post-secondary institutions, the national need for pharmacists is expected to continue its upward trajectory through 2020.⁷

Additionally, we are now facing a *new* shortage within the pharmacy workforce: a shortage of trained *pharmacist providers* who are also experts in preventive medicine and the management of chronic diseases. In California, the recent passage of Senate Bill 493, which mandates a broader recognition of Advanced Practice Pharmacists (APP), will make the emerging shortage of pharmacist providers more urgent.⁸

In California, the passage of Senate Bill 493 is expected to expand the roles for pharmacists in health care teams in an effort to improve the access, quality, efficiency, and affordability of the healthcare delivery system. Community pharmacists will now be able to provide direct patient care services, while directly billing insurance companies.⁹ Moreover, this approach has been cited to decrease the need for high-risk patients to enter hospitals, lowering overall healthcare costs.¹⁰ Therefore, it is critical that future

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doctor of pharmacy (PharmD) graduates have the training to assume this expanded provider role. Additionally, pharmacists are still crucial in settings such as drug discovery and development in academia and commercial research, as well as in regulatory sciences within the government agencies such as the Department of Public Health and the Food and Drug Administration.

To meet the new educational demands of the 21st century, the Accreditation Council for Pharmacy Education (ACPE) recently proposed new standards for the didactic and experiential educational requirements of the PharmD curriculum. Although a number of pharmacy schools are undergoing curricular reforms to follow these new standards, we believe that pharmacy education should start at the undergraduate level. According to the new ACPE standards and guidance, pharmacy graduates need to be “practice-ready” and “team-ready” in order to collaborate with other healthcare providers to provide patient-centered care.¹¹ By setting high standards of pre-pharmacy undergraduate education and by introducing PharmD courses at the undergraduate level, we hope to not only better prepare our students for the rigors of the PharmD curriculum and training programs (e.g., residency, fellowship), but also to better equip them as future healthcare providers.

To improve the pre-pharmacy education to meet this growing demand, University of California, Irvine (UCI) developed a Bachelor of Science (BS) in Pharmaceutical Sciences, graduating its first cohort in 2010, with the goal of offering a comprehensive undergraduate education for pre-pharmacy students to better prepare them for the rigors of the PharmD curriculum. Although UCI does not have a pharmacy school and is only in the early stages of developing one, it is currently the only west-coast institution to offer a BS in Pharmaceutical Sciences and one of only seven programs in the nation. In this manuscript, we share our preliminary experience with our curriculum and highlight its features in an effort to encourage other institutions to enhance the learning experience of their pre-pharmacy students.

Educational activity and setting

Overview

UCI has been ranked as the top feeder institution by the Pharmacy College Application Service (PharmCAS) in 2013-14 and 2014-15, with an average acceptance rate of 85% to pharmacy schools.¹² In 2007, UCI started offering a BS in Pharmaceutical Sciences in an effort to improve the pre-pharmacy education of this large applicant pool. At present, there are only seven universities in the US that offer a BS in Pharmaceutical Sciences, with UCI being the only west-coast institution (Table 1). The successful transition of UCI undergraduate pre-pharmacy students into graduate health-related programs attests to the high caliber of students and the supportive environment developed within the pharmaceutical sciences department. Based on the 2016 student exit survey (n = 106), over one-quarter of graduating seniors were enrolled in post-secondary health-related programs (PharmD, MD, PhD), with an additional 40% planning to pursue post-secondary education.

The teaching philosophy of the UCI pharmaceutical sciences curriculum is based on achieving five educational goals: 1) deep and conceptual understanding of the basic sciences, 2) critical thinking and problem-solving skills, 3) exposure to various fields in pharmacy through seminars and internships, 4) written and oral communication skills, and 5) knowledge of the importance of self-care and wellness. This approach is unique to UCI, which strives to expose undergraduates, beginning within the first year, to pharmacy-relevant coursework (Table 2). In order to achieve the first three goals, students are immersed throughout the four-year duration of the program to pharmaceutical-specific coursework and professional internships. In contrast, the majority of programs limit pharmacy-specific coursework to the final two years of study (Table 3), with the majority not being actively involved in helping students find valuable internships or connecting them with faculty mentors for undergraduate research. Additionally, to ensure students are equipped with strong written and oral communication skills, students are required to complete a course entitled “Speaking About Science,” that is dedicated to writing and communicating new advancements in biomedical and pharmaceutical sciences. Moreover, no program provides a course, such as “Life101,” that strives to instill within students the importance of self-care and wellness. “Life101” is focused on improving student mental and physical well-being, crucial not only in the highly stressful environment of an undergraduate science curriculum, but in the post-secondary PharmD setting.

Program specifics

A deep understanding of the basic sciences is an essential component of the pre-pharmacy curriculum at UCI. These courses not only provide a solid foundation for the more challenging science courses within pharmacy programs, but they also teach students

Table 1
Institutions that offer bachelors of science in pharmaceutical sciences.

Institution	Location
University of California, Irvine ¹³	Irvine, California
Purdue University ¹⁴	West Lafayette, Idaho
University of Rhode Island ¹⁵	South Kingstown, Rhode Island
City University of New York College ¹⁶	Jamaica, New York
University of Michigan ¹⁷	Ann Arbor, Michigan
Albany College of Pharmacy and Health Sciences ¹⁸	Albany, New York
University of Toledo ¹⁹	Toledo, Ohio

Table 2
UCI Pharmaceutical Sciences four-year curriculum²⁰.

Year	Fall	Winter	Spring	Summer (Recommended)
1	General Biology BIOSCI 93 General Chemistry CHEM1A Writing 39B Pharmaceutical Sciences Seminar PHRMSCI 1	General Biology BIOSCI 94 General Chemistry CHEM 1B Writing 39 A	General Chemistry & Lab CHEM 1 C/11C Math 2 A General Education	General Chemistry Lab CHEM 1LD
2	Genetics BIOSCI97 Organic Chemistry CHEM 51 A/1LD Math 2B Research Safety BIOSCI 194 S	Biochemistry BIOSCI 98 Organic Chemistry CHEM 51B/51LB Life101 PHRMSCI 42 Electives	Molecular Biology BIOSCI 99 Organic Chemistry 51 C/51LC Ethics Research PHRMSCI 76 Speaking Science PHRMSCI 90	Speaking Science PHRMSCI 90 Organic Chemistry CHEM 51LD
3	Physiology & Lab PHRMSCI 120/120 L Physics PHYSICS 3 A Scientific Writing BIOSCI 100 Research PHRMSCI 199 or BIOSCI 199	Molecular Pharmacology PHRMSCI170A Physics PHYSICS 3B/LB Statistics 7 or 8	Molecular Pharmacology PHRMSCI 170B Physics PHYSICS 3C/LC General Education *	Microbiology & Lab BIOSCI M122/122L Internship
4	Research PHRMSCI 199 or BIOSCI 199 Biophysical Chemistry PHRMSCI 171 Topic Pharmaceutical Sciences PHRMSCI 172 Biopharmaceutics Nanomedicine & Lab PHRMSCI 174/174L General Education Research PHRMSCI 199 or BIOSCI 199	Math 2D or 3A Research PHRMSCI 199 or BIOSCI 199 Medicinal Chemistry & Lab 177/177L General Education Electives Research PHRMSCI 199 or BIOSCI 199	Research PHRMSCI 199 or BIOSCI 199 Pharmacotherapy PHRMSCI 173 Pharmacogenomics PHRMSCI 163 Human Anatomy BIOSCI D170	PHRMSCI 197

Note: General education, elective, and research courses may be taken throughout the curriculum.

critical thinking and problem-solving skills that they need as future pharmacists. These skills are vital as presented by one article, which linked strong critical thinking skills as a positive predictor for practice-based course success.²¹

The first two years of our curriculum is a hybrid of a typical biology and chemistry undergraduate curriculum. We differentiate our program by continually exposing students, throughout the four-year duration, to courses and information relevant to future careers in pharmacy and pharmaceutical sciences. This is evident in the types of topics covered in the pharmaceutical sciences courses (Table 4). Students take upper division pharmaceutical sciences courses during the last two years of the curriculum. Our upper division courses are “Molecular Pharmacology,” “Pharmacogenomics,” “Medicinal Chemistry,” “Biophysical Chemistry,” “Biopharmaceutics and Nanomedicine,” and “Human Physiology” (Tables 2 and 4).

Unique to the UCI program, is the introduction of pharmaceutical sciences undergraduates to clinical applications of drugs through a course entitled “Pharmacotherapy.” Typically this course is offered at the graduate level, as no other BS in Pharmaceutical Sciences programs offer this course. The course is taught by clinical pharmacists who offer discussion-based lectures utilizing real-world patient cases, while teaching students critical thinking and problem-solving skills. The course also exposes students to what clinical pharmacists do in outpatient and inpatient settings.

Effective learning in both didactic and laboratory courses is heavily dependent not only on conceptual understanding of the topics, but also critical thinking skills, which extend beyond rote memorization. Students are required to take laboratory courses in medicinal chemistry and in biopharmaceutics/nanomedicine and are presented with assignments that are often tackled in drug discovery and development laboratories of pharmaceutical companies.

Communication skills, both written and oral, are an integral component of our curriculum. Students are required to write research papers for medicinal chemistry and biopharmaceutics/nanomedicine laboratory courses. Students are also required to take a speech course entitled “Speaking About Science.” In this speech course, students not only learn the fundamentals of giving scientific speeches, but they also learn how to give presentations in public settings. Communication skills are emphasized throughout the curriculum; in both classroom and in non-classroom settings. To accomplish this, pharmaceutical and biomedical sciences research courses (PHRMSCI 199 and BIOSCI 199) require students to write research grant proposals and present their work at the annual UCI Spring Undergraduate Research Opportunities Program Symposium, which is open to faculty, students, and the general public. We feel this provides our students sufficient opportunity to practice disseminating their research to both lay and academic audiences. This is key as one study suggests a major limitation of undergraduate pre-pharmacy programs is the predominant approach of communication training being isolated to the classroom setting.²³ We feel it is vital our students possess the skills to disseminate their research to a broad audience, as the general public will be their future patients.

To further foster a collaborative and supportive learning environment, we promote a free peer-to-peer tutoring service, available

Table 3
Comparison of bachelor of pharmaceutical sciences course curriculum.

Institution	Program Similarities & Differences to UCI Pharmaceutical Sciences
Purdue University ¹⁴	Similarities: Four-year undergraduate degree program that begins with foundational coursework in chemistry, biology, and physics. Differences: Pharmaceutical sciences specific courses are limited to the final two years of study. No pharmaceutical sciences courses directly focused on pharmacogenomics/epigenetics or pharmacotherapy. No wellness course such as Life101. Limited information in regards to student mentorship.
University of Rhode Island ¹⁵	Similarities: Four-year undergraduate degree program that begins with foundational coursework in chemistry, biology, and physics. In addition, students can take part in the pharmaceutical sciences orientation course, which helps to prepare them for professional internships. Provides a pharmaceutical sciences course on pharmacogenomics. Differences: UCI developed a specific course focused on students developing their scientific communication skills. Pharmaceutical sciences courses are limited to third and fourth-year students, with no pharmaceutical sciences course focused on pharmacotherapy. No wellness course such as Life101.
City University of New York College ¹⁶	Similarities: Four-year undergraduate degree program that begins with foundational coursework in chemistry, biology, and physics. Provides additional honors for students who take part in independent research under the guidance of a faculty member. Differences: Peer mentorship programs are general, not actively connecting peer-to-peer pharmaceutical sciences students. Pharmaceutical sciences courses are limited to third and fourth-year students. No pharmaceutical sciences courses directly focused on pharmacogenomics/epigenetics or pharmacotherapy. No wellness course such as Life101.
University of Michigan ¹⁷	Similarities: Four-year undergraduate degree program that begins with foundational coursework in chemistry, biology, and physics. Differences: Pharmaceutical Sciences courses are limited to third and fourth-year students. No pharmaceutical sciences course directly focused on pharmacogenomics/epigenetics or pharmacotherapy. Peer mentorship programs are general, not actively connecting peer-to-peer pharmaceutical sciences students. No wellness course such as Life101.
Albany College of Pharmacy and Health Sciences ^{18*}	Similarities: Program begins with foundational coursework in chemistry, biology, and physics. Students begin to be introduced to deductive reasoning and how to develop a research question within their first year. Differences: Combined BS/MS pharmaceutical sciences program. Two tracts within the B.S. in P.S. (pharmacology or pharmaceuticals). No pharmaceutical sciences course directly focused on pharmacogenomics or pharmacotherapy. No wellness course such as Life101.
University of Toledo ¹⁹	Similarities: Four-year undergraduate degree program that begins with foundational coursework in chemistry, biology, and physics. Differences: Pharmaceutical Sciences courses are limited to third and fourth-year students. Required internship for graduation. Five majors within the Pharmaceutical Sciences degree program: 1) Cosmetic Science and Formation Design 2) Medicinal and Biological Chemistry 3) Pharmaceutics 4) Pharmacology/Toxicology 5) Pharmacy Administration. No pharmaceutical sciences course directly focused on pharmacogenomics/epigenetics or pharmacotherapy. No wellness course such as Life101. Provides a Pharmacy Summer Camp for rising high-school seniors to learn about the Pharmaceutical Sciences Program.

to pharmaceutical sciences majors. Peer tutors gain not only course credit (PHRMSCI 192), but the opportunity to further improve their communication and empathy skills. The program also provides pharmaceutical sciences students with easy access to free course material assistance.

Almost all of our undergraduate students participate in pharmaceutical and biomedical sciences research courses by joining the research teams of the faculty (we currently have a total of 14 departmental faculty and nine affiliated faculty). Students are formally connected to UCI faculty by participation in undergraduate research courses (PHRMSCI 199). In turn, these courses provide access to a university-wide “clearing-house” of available undergraduate research opportunities such as grant writing workshops, research methodology workshops, and funding opportunities, affording an easy-to-use platform to offer structured training in research (Table 5). In addition to research experience, during the summer of the third year, we offer internships in our curriculum, providing our students with the opportunity to gain hands-on experience in various pharmacy-related fields (Table 5). One of our internship programs is offered as a collaborative effort with the Compliance Office of the Food and Drug Administration (FDA) in Southern California during the summer after the completion of the third year. Students apply for this internship during the spring quarter of their third year. On average, every year about thirty students apply for this internship and two students are selected. During this summer internship, our students undergo a structured training program to learn about the responsibilities of the Compliance Office. After completing this training, the students work with the FDA compliance officers and assist them in various projects that result in issuing injunction or seizure letters on the safety of pharmaceuticals and food.

We also believe that future pharmacists and other health care providers need to learn about self-care and wellness. To fulfill this need, we developed a course entitled “Life101.” The course is considered very popular among our students, as reflected in the annual increase in enrollment and course evaluations. Since the priority for enrollment in “Life101” is given to pharmaceutical sciences students, non-pharmaceutical sciences majors are often wait-listed. In spite of this limitation, non-pharmaceutical sciences majors comprise 43% of online and 26% of in-class students. These percentages could be higher if the enrollment was not limited to a certain number of students, which further attests to the course’s popularity. The course is considered one of the highest student-rated UCI courses, with an average overall course evaluation of 3.94/4.0. In this required course, offered both online and in-class, students learn

Table 4
UCI Bachelors of Pharmaceutical Sciences course descriptions.²²

Course Title	Course Description
New Student Seminar (PHRMSCI 1)	The course offers weekly seminars consisting of presentations by faculty, professional staff, and student academic advisors to provide information pertinent to Pharmaceutical Sciences major, and to connect students with on-campus resources, learning skills, and special programs.
Life 101 (PHRMSCI 42)	The course is designed to help students make positive lifestyle choices by offering latest scientific work on stress management, nutrition, exercise, and lifestyle choices. The course is offered online and in-class.
Ethical Conduct of Research (PHRMSCI 76)	The course is designed to cover ethical responsibilities of researchers (students and investigators) through the use of discussion and case studies. Topics include the high standards of science, the responsible conduct of research, animal experimentation, and clinical trials in relation to pharmaceutical sciences.
Speaking about Science (PHRMSCI 90)	The course teaches students scientific communication skills. They learn to prepare and present public speeches and scientific power point presentations.
Human Physiology (PHRMSCI 120)	The course is designed to prepare students for a career in healthcare (medicine, pharmacy, dentistry, etc.) and for basic research careers that require basic knowledge of how the human body functions. All major organ systems of the human body and how they function are covered.
Human Physiology Lab (PHRMSCI 120L)	The course utilizes an online and active learning environment to provide practical knowledge of topics in human physiology. Students participate in group projects to improve basic laboratory skills and working in a team-setting.
Pharmacogenomics (PHRMSCI 163)	The course covers the genetic and epigenetic basis of inter-subject variability in response to drugs. The course focuses on drug efficacy, safety, and optimization in pharmacotherapy. Emphasis is given to understanding the genetic mechanisms of polymorphisms in the pharmacokinetics and pharmacodynamics of therapeutic drugs.
Molecular Pharmacology I (PHRMSCI 170A)	The course covers basic concepts in pharmacokinetics, pharmacodynamics, mechanism of action, adverse effects and drug interactions of drugs at the molecular and cellular levels. The drugs that target hypertension, diabetes, and dyslipidemia are covered along with natural products and selected dietary supplements. The course also includes case based discussions on clinical correlation.
Molecular Pharmacology II (PHRMSCI 170B)	This is the second part of Molecular Pharmacology. It covers drugs that target the nervous system, immune system, those used to treat cancer, and recreational drugs.
Biophysical chemistry (PHRMSCI 171)	The course covers thermodynamics and kinetic fundamentals as applied to problems relevant to pharmaceutical sciences, including receptor/enzyme-ligand interactions and fundamentals of biophysics necessary in pharmaceutical sciences to deduce structure determination and biomolecular spectroscopy.
Topics in Pharmaceutical Sciences (PHRMSCI 172)	The course presents students with various career options and is taught by guest lecturers from multiple disciplines, including faculty from research courses. The course consists of weekly meetings discussing different fields of research, study, careers, and graduate school opportunities in pharmaceutical sciences. The course also helps students select course electives relevant for their future career goals.
Pharmacotherapy (PHRMSCI 173)	The course is focused on understanding the principles behind pharmacology and its application to diseases. It is designed to teach students about the clinical application of medications for selected disease states.
Biopharmaceutics & Nanomedicine (PHRMSCI 174)	The course introduces theories and tools of new drug formulations. Topics include novel therapeutics based on biological materials, pathological characteristics utilized to achieve maximal efficacy, specificity, and drug delivery systems based on emerging nanotechnology.
Biopharmaceutics & Nanomedicine Lab (PHRMSCI 174L)	This lab course introduces students to cancer drug screening using cellular models, including basic cell culture, cytotoxicity assays, cell analysis. Drug therapeutic efficacy is tested using a live animal model, which includes drug circulation tests, and tumor eradication and imaging experiments.
Medicinal Chemistry (PHRMSCI 177)	The course offers an introduction to the basics of drug activity and mechanisms. Course covers strategies used to identify lead compounds including natural product chemistry, combinatorial chemistry, molecular modeling, and high-throughput screening. Students also learn about the relationship of molecular structure to pharmacological activity.
Medicinal Chemistry Lab (PHRMSCI 177L)	This lab course is designed to complement the topics covered in PHRMSCI 177.
Stem Cell Therapy (PHRMSCI 178)	The course focuses on the advancements of regenerative medicine in the area of stem cells. Topics are focused on stem cell biology and in vivo imaging modalities, including molecular, nano- and miro-engineered tools for in-vivo imaging necessary for assessment of regeneration.
Tutoring in Pharmaceutical Sciences (PHRMSCI 192)	The course offers a peer-to-peer tutoring program with Pharmaceutical Sciences student peers.
Professional Internship (PHRMSCI 197)	The course offers students hands on and supervised experience in various pharmacy related fields and gives them the opportunity to develop leadership and professional skills necessary for competitive placement for jobs. Students are expected to complete at least 100 h at the internship sites.

(continued on next page)

Table 4 (continued)

Course Title	Course Description
Independent Study in Pharmaceutical Sciences (PHRSMC 198)	The course offers students the opportunity to work with a faculty member on a specific project. Students are expected to commit between 3 and 12 h per week, dependent on the number of units. Students are required to submit a written report at the conclusion of each quarter.
Undergraduate Research (PHRMSCI 199)	The course offers research and hands on experience in the laboratory of Pharmaceutical Sciences faculty. Students participate in research group meetings and submit a quarterly written report.
Honors Research in Pharmaceutical Sciences (PHRMSCI H199)	The course is built on PHRMSCI 199. Students commit 10–15 h per week and they need to write a report and also present their work at the research symposium.

about stress management, healthy lifestyle choices, nutrition, exercise, emotional intelligence, mindfulness, personal finance management, and being socially responsible. Findings comparing student responses at the start and end of the course, showed significant improvements in student understanding in all course topics.

In an era when stress and anxiety are rampant on college campuses, the need for stress coping skills is only growing. A 2014 study by the American College Counseling Association showed that 52% of college students seeking help had severe psychological problems compared to 44% in 2013 and 16% in 2000, further demonstrating the growing epidemic of stress and anxiety in college students.²⁶ Given that stress is a growing crisis on college campuses, teaching our students the importance of stress management, adopting healthy lifestyle choices, and self-care will not only help them to be successful in their undergraduate education, but will also inspire them to become future healthcare providers who serve as models of wellness for their patients.

In order to assure the achievement of these goals, students' performance in pharmaceutical sciences is not only assessed in individual courses, but is also evaluated in a comprehensive online exit survey prior to their graduation. The exit survey is comprised of two sections: a comprehensive case exercise that assesses the conceptual understanding of the knowledge gained in upper division courses and a questionnaire assessing the student's experience in pharmaceutical sciences. Specifically, students are asked to provide an overall numerical score [1 (lowest) – 10 (highest)] to summarize their experience in the pharmaceutical sciences major and how they would rate their final two years of pharmaceutical sciences courses and electives. Additionally, students provide qualitative feedback to four questions: 1) "What was the best part of the overall four-year experience as a pharmaceutical sciences major? Please provide one specific example and why"; 2) "Were there any challenges during your experience as a pharmaceutical sciences major? If yes, how could the situation have been handled better or any suggestions on improvement in this matter?"; 3) "Do you feel that the pharmaceutical sciences major has prepared you well for your future career plan?"; and 4) "Please provide why/how you feel it has or has not prepared you (specific examples are encouraged and helpful)." Students are asked to provide information about their post-graduation objectives, whether they are pursuing graduate education, employment, or join the military. Exit survey results enable us not only to gain direct feedback from recent graduates on how to further improve the program, but to also collect data on the acceptance of our students into graduate health-related programs and their future plans.

Findings

We believe that our undergraduate program is on a trajectory for further success, as evident by the exponential growth since 2010. In 2010, seven students graduated with a BS in Pharmaceutical Sciences at UCI. As of spring of 2017, 874 students have graduated with a BS in Pharmaceutical Sciences and almost 70% of these students have already been accepted or are in the process of applying to pharmacy schools. In the coming years, we project an annual graduation rate of 250 students per year.

Although the pharmaceutical sciences major is one of the most challenging majors on our campus, the average grade point average (GPA) of our students is 3.4, with over 50% of students obtaining the Dean's Honor List with a GPA over 3.5. The rigors of the course-load do not create an unfavorable opinion of the program. Based on our spring 2016 exit survey, 74% of students rated their overall experience as 8 or better (on a scale of 1–10, with 10 being the best). More importantly, many of our former students, currently enrolled in pharmacy schools, attribute their current success to their undergraduate education at UCI (data on file). Between 2013 and 2015, nearly half (48%) of our students received Undergraduate Research Opportunity Program (UROP) grants, enabling them to participate in undergraduate research and share their findings at the UCI annual Undergraduate Research Symposium. Moreover, in 2014, students who participated in the FDA internship program received national awards and recognition for their contribution to the mission of the FDA.

Overall, some of the major strengths of our program are the in-depth course-curriculum, encouraging students to participate in pharmacy-relevant research, giving students opportunities for hands-on-experience within the pharmaceutical field, teaching students the importance of self-care and adopting a healthy lifestyle, and the development of student communication skills. This unique approach has the potential to position our students to successfully pursue a wide-range of graduate programs, including PharmD programs, and joint graduate programs, such as PharmD/PhD programs.

Areas for improvement

The UCI BS in Pharmaceutical Sciences is a continually evolving program, in our effort to provide the best environment for our

Table 5
UCI professional internships and research opportunities.

Professional Internship		Selected Internships ²⁴
Requirements ²⁴	Program Description ²⁴	
Junior or Senior Student Standing	A 4-unit summer internship that connects UCI Pharmacy undergraduate students with industry and government partners.	UCI Health Medical Center Pharmacy
Minimum cumulative Grade Point Average (GPA) 3.30	Students are expected to complete, at minimum, 10 h per week, during the 10-week summer program.	U.S. Food and Drug Administration
Enrollment Pharmaceutical Sciences 197	Students are expected to not only meet satisfactory expectations at the internship site (site supervisor evaluation), but also to complete a 3-page report summarizing the experience, oral presentations, and attend course discussions.	Irvine Pharmaceutical Services Children's Hospital of Orange County Local Pharmacies
Pharmaceutical Sciences Research Opportunities		
Course Name	Requirements	Course Highlights
Research in Pharmaceutical Sciences (PHRMSCI 199) ²⁵	Discretion of Pharmacy Faculty Advisors Time Commitment: 10–15 h per week	Understanding the process of research and discovery. Enhancing written and oral communication skills. Participation in the annual undergraduate research symposium. Faculty-student mentorship.
Honors Research in Pharmaceutical Sciences (PHRMSCI H199) ²⁵	Prior approval for course enrollment from Pharmaceutical Sciences Faculty Advisor. Three prior quarters of approved research courses (PHRMSCI 199) Time Commitment: 15 h per week	A more advanced level of PHRMSCI199. Participation in the annual undergraduate research symposium. Successful completion of the course will result in designation of the “Honors” on the student's transcript.

present and future pre-pharmacy undergraduate population. One of the major goals in sharing our program design and experiences was to help provide novel approaches to further spur and promote cross-communication with other current and future BS in Pharmaceutical Sciences programs. We recognize the importance of adapting our curriculum to the needs of our students and faculty. To meet this objective, we continually assess our program based on our students' and faculty feedback and strive to improve the curriculum. Since the inception of this program, three required courses, "Physiology," "Life101," and "Speaking about Science," and one elective course, "Pharmacogenomics," were added to the curriculum. A major limitation to our program is the lack of collecting longitudinal data from our alumni who have graduated from pharmacy schools. We have started to develop an alumni database and we plan to survey our graduates four to five years post-graduation.

Discussion

The UCI pharmaceutical sciences program offers a unique curriculum, which is specifically tailored to providing undergraduate students with the skillset necessary to be successful in their future pharmacy programs. Due to the growing need for well-trained pharmacists, we feel our program provides a unique combination of both course-work and experiential opportunities in research and pharmaceutical fields. This will provide students with the skills to be successful in pharmacy school and be effective in their future careers. Indeed, the growing demand for this program, has resulted in a projected 1000 students within the pharmaceutical sciences program by 2020 with an annual 250 students graduating. According to 2016 Academic Analytics, LLC, in spite of our small yet growing faculty, the UCI Department of Pharmaceutical Sciences is ranked in the top 10% of the 88 departments of pharmaceutical sciences nationwide (data on file). We believe this is due to the cutting edge research conducted by the faculty and the high priority we place on providing students with both didactic and experiential learning in research and internship settings. We aim to provide our students not only with a sound educational foundation, but also to develop students' communication, interpersonal skills, and critical thinking. All of these areas have been found to be critical components in fostering future success, but only a few of these areas are typically met in the majority of undergraduate pre-pharmacy curricula.^{23,26–28} We hope our approach can provide a "blueprint" for other programs seeking to provide a more enriching environment for their pre-pharmacy students.

Summary

We believe that our undergraduate curriculum has the potential to prepare students to become lifelong learners, critical thinkers, problem-solvers, team players, and wellness advocates. Our experiential components of our curriculum, internships and research courses, also expose our students to challenges they will face in the workplace, and inspires them to become leaders. To address the shortage of APPs in California and nationwide, we must improve not only the educational standards of the PharmD curriculum as now required by ACPE, but we must also enhance our pre-pharmacy curriculum. We believe that training should start in undergraduate programs to yield 21st century pharmacists who are both drug experts and wellness advocates in collaborative health care teams. Our unique undergraduate program in pharmaceutical sciences is paving the way towards achieving these goals.

Conflicts of interest

None.

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