

## Research article

## Pharmacy undergraduate programs: Development of an adaptive curriculum for student success

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## ABSTRACT

**Objectives:** Applicants for graduate work in Pharmacy on paper appear competitive, but upon entering a Doctor of Pharmacy (PharmD) program many students struggle with course work, course load, and pharmacologic topics in their first-year studies. In addition to math and science, undergraduate candidates need to have skills that enable them to be adaptable and creative learners. The Pharmacy Undergraduate Program (PUP) at the University of Southern California (USC) has been attentive to these educational needs. In this manuscript we will show how our program has been successful in generating well-prepared and successful candidates for graduate programs (pharmaceutical, clinical, medical, and other) and employment in pharmaceutical fields.

**Methods:** A review of current student enrollments (N = 121), graduated student annual survey data (N = 50), student research data (N = 68), and ongoing course surveys have been used to detail information related to PUP.

**Results:** Students who have graduated from PUP have been successful post-graduation. Graduates of PUP have gone on to PharmD programs 44% (22/50); medical school 16% (8/50); PhD programs 24% (12/50); full-time employment 6% (3/50); internship/volunteer positions 10% (5/50); taken a gap year 4% (2/50); and MS/MA program 2% (1/50).

**Conclusions:** PUP has been successful in helping the admission of our students into graduate degree programs related to pharmaceutical sciences and medicine. This success can be attributed to the dynamic nature of the course offerings and the creativity of the teaching faculty, which leads to students being well-prepared to tackle the rigors of their graduate studies after leaving the program.

## 1. Introduction

Pharmacy school admission rates at universities in the United States seem to have plateaued, while the application rates seem to oscillate from high to low from year to year and the number of accredited schools continues to rise [1–3]. The fluctuation of potential applicants has produced a pool of students who appear competitive on paper, but upon entering a Doctor of Pharmacy (PharmD) program may struggle with course work, course load, and pharmacologic topics in their first year studies [4–6]. Part of the challenge many of the students face may be related to their undergraduate prerequisite science courses that are more focused on basic content

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and not on how these topics relate to the human health. For example, a typical undergraduate Chemistry degree does not fully take into consideration how medicines and human physiology interact, nor do they fully appreciate the social and economic implications of medical products. This contrasts with undergraduate degrees with a focus on pharmaceutical sciences, pharmacology, or pre-pharmacy curriculum where there is greater emphasis on the biology and human condition of medical products. Notably, these latter programs tend to produce stand-out applicants who enter their first year of pharmacy school well prepared [5,7–10]. Unfortunately, programs such as these are few in number compared to the more commonly taken majors in Biology, Chemistry, Biochemistry, etc.

For over 10 years, career paths for PharmD's have been rapidly evolving beyond the traditional roles of fulfilling prescriptions and treating patients in an ambulatory or community care setting. As such, the undergraduate pharmacy programs must also evolve beyond the traditional science curriculum [11]. Pharmacists have expanded into roles as educators, managers, mentors, business/product developers, leaders, researchers, and policy experts [1,12,13]. The change in role has been dictated on the location of their practice, experience, competencies, interest, and changes in the job market. To best serve the next generation of pharmacists, these changes need to be reflected and incorporated into undergraduate educational programs as well.

The flaws of the typical undergraduate science degree presented briefly above, coupled with the ever-changing career paths for PharmD motivated the faculty at the University of Southern California's School of Pharmacy to develop a series of undergraduate programs (i.e., Pharmacy Undergraduate Programs [PUP]) with a focus on Pharmacology and Drug Development. The goal of these programs is to deliver course content to meet the ever-changing needs of the 21st century PharmD candidates. Since the program's inception, six years ago, we have continued to monitor the career landscapes and have refined and expanded course content to best prepare our undergraduate students for pharmacy and drug development related careers in the 21st century. This has been our operational philosophy in PUP since its inception.

While no single job description encapsulates the ~275,000 pharmacist positions in the United States, most pharmacists are typically employed in clinical practice, research settings, government, or non-profit organizations [9,14]. Clinical practice settings for pharmacists vary widely from independently owned and operated drugstores to international superstore chains, academic medical centers, military bases, urgent care clinics, and in cannabis dispensaries in legalized states [15]. Research settings are equally broad for pharmacists ranging from drug discovery to translational drug testing, diagnostics, and global regulatory science positions [16,17]. Additional career settings include healthcare policy, health economics, patient advocacy, government lobbyists, data analyst, and other future-proofing non-traditional roles (such as, integrated technology/robotics, ambulatory and managed care, and pharmaceutical scientists) [13,18]. Today's pharmacists participate in a world of professional and individual diversity, often with little or no additional training to position them as local, national, or global leaders within their areas of interest [19,20].

Acknowledging the new educational needs and diversified interests of modern pharmacy students, the Accreditation Council for Pharmacy Education (ACPE), has supplied guidance related to the key educational requirements of an accredited PharmD curriculum [21]. In addition to traditional pharmacy coursework, the ACPE suggests that educational programs should "impart[s] to the graduate the knowledge, skills, abilities, behaviors, and attitudes necessary to solve problems" and acknowledges that training should afford graduates with the ability to collaborate with a broad range of people [22]. Pharmacy schools do have the ability to be creative and adapt electives and co-curriculars to the changing face of pharmacy to make graduates successful in their future careers [23]. Some academic institutions are looking toward undergraduate programs that facilitate life-long learning aspirations alongside practical and theoretical pharmacy skills to enrich their candidate pools [10,24].

Now entering its sixth year, the University of Southern California's PUP provides students with immersion in a broad range of pharmacy related topics including pharmaceutical science, clinical practice, health economics, social science, pharmacology and drug development, and regulatory science. PUP has several research opportunities available for students interested in bench science, policy analysis, and database research. These research opportunities place the student with a faculty mentor who is currently doing research and will help the student discover and hone valuable research skills. PUP has four-degree tracks for students, including a BA or BS in Pharmacology and Drug Development (PDD) and a BA or BS in Biopharmaceutical Sciences (BPS). In addition, PUP offers three undergraduate minors – Science and Management of Biomedical Therapeutics (SMBT), Foundations in Regulatory Science (FRSC), and Biopharmaceutical Business (BPBU). The program launched with the Pharmacology and Drug Development BS degree and will be enrolling into the other three degrees in 2022. The faculty and staff are diverse in educational background and the coursework cross pollinates, so themes and topics are discussed broadly and approached from different academic vantage points. In this manuscript, we share our experiences developing novel curriculum and underscoring the unique aspects of the curriculum that have made recent graduates successful in their first year of graduate school and beyond.

## 2. Methods

Data is drawn from four sources for this manuscript. We obtained registration and enrollment data to count our current students. We used data from our annual survey for graduates of USC PUP, which asks our students questions related to their educational or career trajectory over the past year after graduation or receipt of their last survey. The annual survey uses qualitative and quantitative measures to obtain data. The first half of the annual survey asks questions related to the student's current educational or employment status. The second half offers open-ended questions that ask students to reflect on the education they received during their undergraduate work. The narratives were analyzed using basic qualitative coding and analysis to look for themes and trends across and among the comments [25,26]. Data related to the number of abstracts and publications was obtained from the student led, faculty facilitated Pre-Pharmacy Society. Course syllabi were collected and reviewed for the entire breadth of our program, and we isolated those courses utilizing active learning methods. We then surveyed the percentage of time these courses employed active learning with

the intent to isolate out any student responses related to success from the annual student surveys. And finally, data was obtained from the course surveys collected for each class prior to final exams from the students who are enrolled in our current curriculum. These data sources will help elucidate the broad scope of the USC PUP, prospects for our students, and will highlight areas of change to meet our student needs.

This manuscript presents descriptive data, which used a mixed methods approach [27]. With a mixed methods approach, we have greater ability to contextualize both quantitative and qualitative data collected about the evaluation of our program. We chose to use these methods due to the low sample size we have currently available for evaluation. This research was approved by the University of Southern California Internal Review Board, under protocol UP-21-00581: Pharmacy Undergraduate Programs: Development of an Adaptive Curriculum for Student Success. All the data accessed for this study was provided in aggregate form, no student names or identifiers were available. Data was reviewed in stages with one of the authors performing the initial review and the others performing secondary and tertiary reviews until saturation and agreement was achieved.

### 2.1. Findings

The USC PUP has grown exponentially each year in its six years of existence. At the time of publication, all of our degree tracks have been fully approved by the university with the newest three-degree tracks enrolling students in the fall semester of 2022. The total number of enrollments in all PUP offered courses between 2016 and 2022 totals 2578 students (Fig. 1). The total number of enrollments represents both major and non-major enrollment and interest in PUP course offerings. Students in the major span all levels of undergraduate education from freshmen to senior (see Fig. 2).

### 2.2. Student demographic findings

Current students in the BS Pharmacology and Drug Development major total 100 and in the BS in Biopharmaceutical Sciences major total 21. At this time there are 24 students enrolled in the SMBT minor, 10 students enrolled in the BPBU minor, and 2 in the FRSC minor. The program is 51% female, 49% male. Ethnic make-up of our current students is displayed in Table 1. To provide some context, the School of Pharmacy in Spring 2022 reported 1172 graduate level students currently enrolled (includes MS, PhD, and PharmD) [28]. Schoolwide, USC reported a student body in the 2021–2022 academic year of 21,000 undergraduates and 28,500 graduate and professional students for a total of 49,500 active students [29]. Student enrollment by unit level within PUP is divided out over Seniors 40% (>96 units completed); Juniors 25% (65–96 units completed); Sophomores 13% (33–64 units completed); and Freshmen/First-Year Students 22% (<32 units completed). Our program was listed in the *CommonApp* in 2020, the application website for enrollment of first year and transfer students into USC, where students could choose to directly enroll into one of our programs. Prior to this time, the bulk of our students transferred from a different major within the university into one of the programs majors.

### 2.3. Educational program findings

Appendix 1 and 2 contain an abbreviated list of our currently offered courses for PUP. All faculty who teach in PUP are full time and have appointments in the School of Pharmacy and Keck School of Medicine. The faculty in the program teach at differing percent effort at the undergraduate level, spanning from 15% to 80% effort, with their remaining percent effort allotted to clinical care, graduate

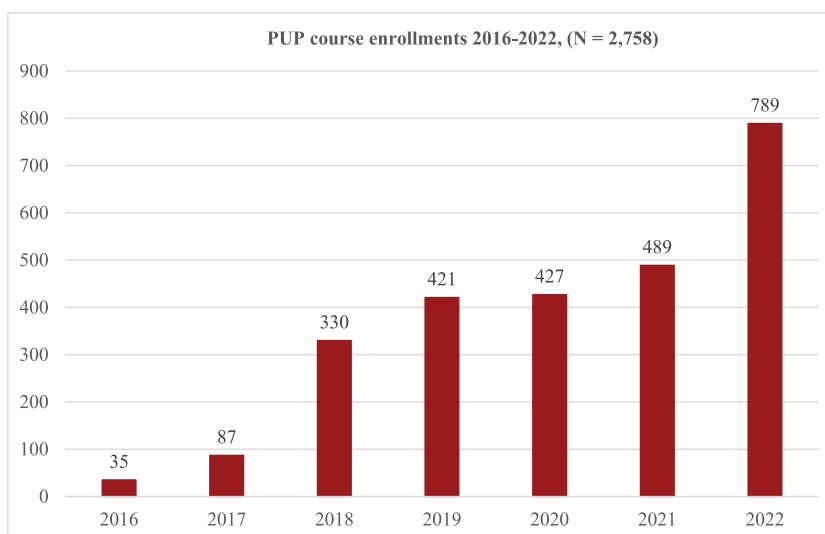
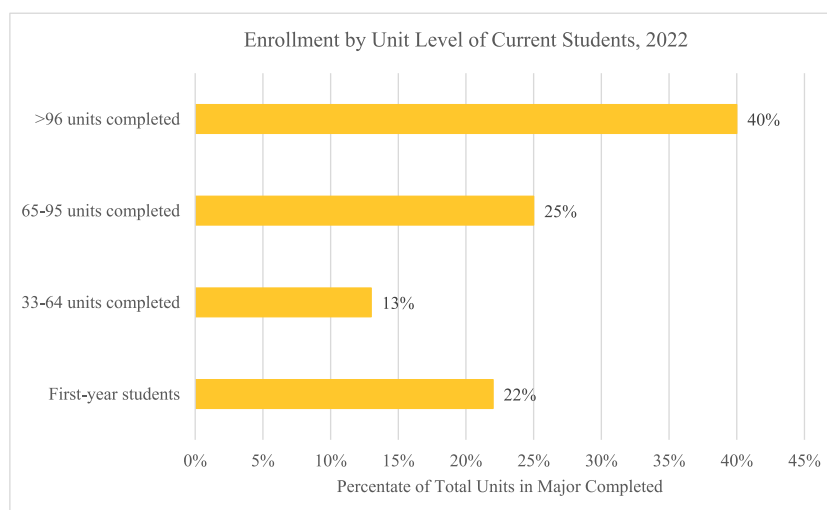


Fig. 1. PUP course enrollments 2016–2022, (N = 2758).



**Fig. 2.** Enrollment by unit level of current students, 2022.

**Table 1**

Racial and ethnic breakdown of USC student body, 2022.

Race/Ethnicity	PUP Program (N = 121)	USC School of Pharmacy (N = 1143)	USC Student Body (N = 46,000)
Asian	46%	44.94%	18.6%
Caucasian	26%	23.76%	29.4%
Hispanic	14%	6.45%	15.0%
African American	4%	2.95%	5.5%
International	0%	17.40%	22.6%
Other/not specified	0%	4.51%	8.9%

teaching (PharmD, PhD, and MS), research, and service (Table 2). Having faculty engaged in both undergraduate and graduate education provides a group of educators uniquely entuned to the course content needs for graduate school. The academic diversity of our faculty is representative of the diversity of our students and their career interests.

A key facet of PUP is the ability of students to take advantage of the Trojan Admission Pre-Pharmacy Program (TAP). TAP provides PUP seniors with priority for the first interview sessions offered by the School of Pharmacy's PharmD program. TAP students complete their pre-pharmacy coursework while earning their bachelor's degree. Students must maintain a cumulative 3.2 GPA to remain eligible

**Table 2**

Department, degree, undergraduate effort, and research area/mentorship for teaching faculty.

Faculty	Department	Degree(s)	Undergrad. % Effort	Research Area	Research Mentorship
DD	Clinical Pharmacy	PhD	20%	Novel Therapeutics, Neurodegenerative Diseases, Alcoholism	Laboratory – Basic and Translational
TDC	Regulatory and Quality Sciences	DRSc, MA, MS	80%	Biobank Regulation, Ethics, Regulation of Controlled Substances	Policy Analysis, Database
AMB	Clinical Pharmacy	PhD	50%	Chemokines, Vaccine Immunology, Immunology	Laboratory – Basic and Translational
TP	Clinical Pharmacy	PharmD	40%	HIV Pharmacotherapy, LGBTQ + Care	Clinical Rotation Specialty Clinic
EP	Regulatory and Quality Sciences	PharmD, PhD	15%	Drug Regulation, Global Pharmaceutical Market, International Medical Product Regulation	Policy Analysis, Database
FJR	Regulatory and Quality Sciences	PhD	15%	Implantable Medical Devices, Clinical Trial Regulation, Regulation of Pharmaceuticals	Policy Analysis, Database
MJ	Neuroscience	PhD	15%	Neuroplasticity, Behavior, Neurotransmitter Systems	Laboratory – Basic and Translational
CO	Pharmacology and Pharmaceutical Sciences	PhD	15%	Cell Structure and Organization, Physiology	Laboratory – Basic and Translational
MC	Pharmacology and Pharmaceutical Sciences	PhD	15%	Neonatal Gonocytes, Environmental Effects, Male Germline Stem Cells	Laboratory – Basic and Translational
LA	Clinical Pharmacy	PhD	15%	Discovery and Development of Novel Compounds to Treat Alcohol Use Disorder	Laboratory – Basic and Translational

for the TAP program, and all pre-pharmacy courses must be taken for letter grades. TAP provides the students with individual advisement, membership to the student led USC Pre-Pharmacy Society, and access to the School of Pharmacy Student Affairs Office. TAP students must graduate with their bachelor's degree before entering the PharmD program. It is important to note that participation in TAP does not guarantee entry into the USC School of Pharmacy.

To further prepare our PUP students for the rigors of pharmacy school, many of our courses incorporate active learning techniques to help in-depth understanding of the material taught in lectures. Within PUP, our faculty use a broad range of teaching skillsets which are being vertically integrated throughout the undergraduate courses, ranging from debates in ethics to patient case discussions to critical thinking and cooperative games. Active learning is becoming a standard feature of PharmD programs as it encourages students to directly apply knowledge taught in a lecture setting to patient care management, simulating what they will encounter as working pharmacists [30–32]. Many new PharmD students struggle to adapt to this style of learning as active learning is not yet standard practice in many undergraduate programs; most undergraduate STEM curriculum is based on a “learn then regurgitate” model that encourages memorization of facts and concepts for exams but does not lead to long term retention of information [33,34]. To address this significant imbalance between teaching styles and to give the PUP students an advantage, students in our courses are exposed to multiple styles of active learning in our curriculum during their tenure with our program. We have feedback from student evaluations establishing not only a student preference for this style of education, but also their excitement strengthens their understanding of taught concepts through application (Table 3). The feedback in Table 3 is all incredibly positive and many of our responders shared similar comments. We did receive a few negative comments, such as “not sure if my BS prepared me fully” and “the education from my BS only partially prepared me for the intensity of my first year of PharmD”. As the surveys are anonymous, we were unable to follow-up for additional information.

The active learning techniques currently used in our curriculum are summarized in Table 4. Within this table we isolated the percent of time each course uses active learning. Within PUP, we have seen that active learning not only enforces topics and concepts from lecture, but also provides students the opportunity to learn presentation skills, practice public speaking, learn how to debate complex topics, and how to work in teams. The incorporation of active learning techniques in our curriculum provides our PUP students with an even more well-rounded educational experience, while also preparing them for the topics and teaching styles they will encounter after entering their selected graduate program.

PUP has developed a series of progressive undergraduate to master's degrees with the Department of Regulatory and Quality Sciences and currently there are 8 students in the progressive MS in Regulatory Science, 3 student in the progressive MS in Medical Product Quality, 5 students in the progressive MS in Management of Drug Development, and 27 students in the progressive MS in Healthcare Decision Analysis. These progressive degree options give students the flexibility to obtain a master's degree within 2 semesters after receipt of their undergraduate degree. This is carried out best if the student declares their intent at the start of their junior year, this allows for them to take up to 8 units of graduate credits during their senior year. The first cohort of progressive degree students will graduate in the spring of 2022.

#### 2.4. Student research and publication findings

Between 2019 and 2022, the student led Pre-Pharmacy Society (PPS) maintained a database of student abstracts/papers from their members. A total of 68 undergraduate students have conducted research with a USC faculty mentor and have had their work published either as an abstract or manuscript. A total of 85 posters have been accepted for presentation at Drug Information Association (DIA),

**Table 3**  
Themes and example quotes obtained from annual graduates survey<sup>a</sup> from two reflective questions<sup>b,c</sup> (N = 50).

Theme	Comments (n) <sup>d</sup>	Example Quote
1. Enhancement of learning	27	“I really love the undergraduate classes that were taught in the major, as I feel they taught us unique knowledge that we would not have otherwise learned in the standard bio/chem classes. The way these classes enhanced my learning has been really pertinent in my successes in pharmacy school so far and gave me a preview of topics we would be learning in pharmacy school.”
2. Career pathways	24	“Through my courses and guest lecturers, I was introduced to various career pathways within pharmacy, and I was able to gain an immense amount of knowledge and insight about the field.”
3. Opportunities	24	“I am glad I took advantage of all the opportunities this program offered. Through the unique way the courses were taught I was able to gain more experience and it helped me discover what I liked and don't like in pharmacy, and it helped me settle on my career path.”
4. Network of connections	21	“This program allowed me to build a valuable network of connections. Our upper-level classes were small, and it allowed for us to participate in active learning, which also let us get to know our professors better. Because of this style of teaching, I feel like my network of mentors has grown and I am grateful.”

<sup>a</sup> The annual survey contains 19 questions, 16 of which are quantitative and 3 qualitative.

<sup>b</sup> The first qualitative question used here asks: “how did your undergraduate degree program at USC prepare you for success in your current career?”

<sup>c</sup> The second qualitative question used asks: “where there specific experiences from your undergraduate program at USC that you feel have helped you in your current career?”

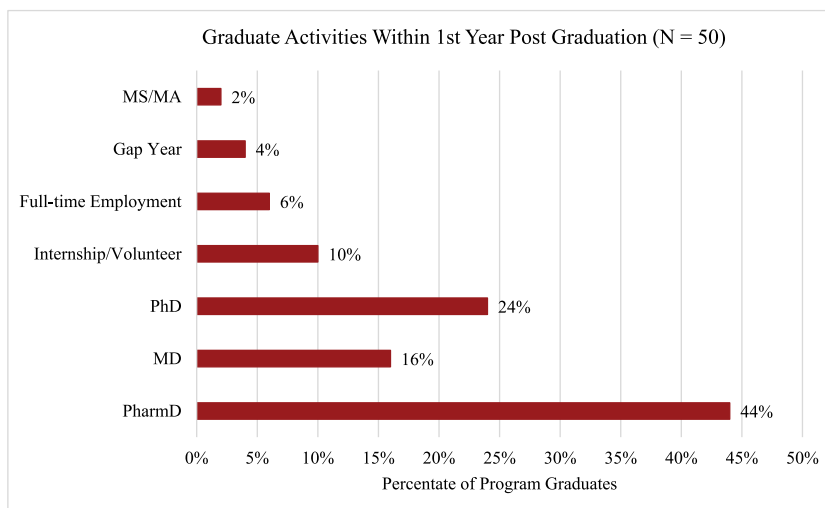
<sup>d</sup> Responses to these prompts have been obtained from 27, 24, and 21 students. The response rate was 27/50 comments for the first question, and 24/50 and 21/50 for the second question.

**Table 4**  
Active learning techniques utilized in PUP curriculum.

Course	Active Learning Technique	Percent of time the Learning Technique is Employed for Education (%)	Description of Active Learning Technique	Additional Skills Learned
Approaches to Pharmacology and Drug Development	Peer-to-peer, active review sessions	35%	Student led presentations	Public speaking, presentation skills
Ethics, Drugs and Society	Scenarios, discussions	50%	Courtroom-style debates of current topics, including a student jury who “decides” which view “wins”	Public speaking, debate skills
Arming the Immune System for Novel Therapies	Group evaluation, large group discussions	5%	Student led discussion of primary literature	Public speaking, data analysis
Plant Medicines in Modern Medicine	Peer-to-peer, in-class demonstrations	35%	Student led valuation of integrative therapies	Public speaking, presentation skills, data analysis
History and Geography of Drugs	Scenarios, role playing	15%	Student role play through historical plagues, “new world” hallucinogens, and development of an advertisement/medical quackery	Teamwork, public speaking, presentation skills
Buzzed: Modern Substance Abuse and Addiction	Scenarios, discussion	50%	Weekly student led and researched presentations related to the topical drug	Public speaking, presentation skills
Mysterious Deaths: From Poisons in Literature and History to Forensic Toxicology	Scenarios, role playing	30%	Student role play game – “Dinner with the Borgia” to uncover the poison and poisoner	Teamwork, data analysis, and strategy

American Pharmacists Association (APhA), and Association of Clinical and Translational Sciences (ACTS). A total of 29 peer-reviewed publications have been accepted by Alcohol (2), Journal of Clinical and Translational Science (1), Vaccine Journal (1), Alcoholism: Clinical and Experimental Research (1), International Journal of Molecular Sciences (1), and Journal of American Pharmacists Association (23).

Students from PUP have been successful in obtaining research funding for their work through competitive fellowships offered by the Provost of USC. The USC Provost’s Undergraduate Research Fellowship provides a stipend of \$1000 (Fall and Spring semesters) and \$3000 (Summer semester). Student’s must apply for each semester and agree to 10 h per week (Fall and Spring) and 20 h per week (Summer) of dedicated research time. In addition, the faculty have consistently been funded through the Undergraduate Research Associates Program (URAP), administered by the USC Office of Undergraduate Programs. The URAP funding provides resources that enable USC faculty to integrate undergraduates into scholarly and professional activities. There are currently 4 URAP grants being used to support PUP student research. These funds are awarded annually through a competitive funding mechanism from the Provost Office. The grant is open for USC faculty with the intent to support research initiatives for undergraduate researchers. On average 50 grants are awarded per cycle. URAP funding is limited to a maximum of \$10,000 per award but has a required mechanism to offer research stipends of \$1500 per semester for students working on the elements of the URAP proposal.



**Fig. 3.** Graduate activities within 1st year post graduation (N = 50).

## 2.5. Graduates annual survey findings

A total of 50 students have graduated from PUP who hold a BS in Pharmacology and Drug Development, 19 students with the SMBT minor, and 1 student with the FRSC minor. Fig. 3 details the academic/career activities of the students who have graduated with their BS. Our graduates are surveyed annually to obtain information about their careers, academic pursuits, volunteer/internship, and earning potentials. Surveys of our recent graduates from 2019 to 2022, show 444% (22/50) have gone directly into a PharmD program. There were 16% (8/50) who have gone on to medical school and 24% (12/50) who have gone on to graduate school (PhD) programs. Students have also gone on to full-time employment 6% (3/50); internships/volunteer positions 10% (5/50); and taken a gap year 4% (2/50). One student is currently enrolled in a MS/MA program, field of study not specified (2%). Undergraduate post-graduation plans published by USC for the class of 2020 show that 89.9% of graduating students had a post-grad plan consisting of full-time employment, fellowship, own venture, continuing education, military service, or other intention [35]. The 2020 report indicates that there were 9.6% still seeking employment or education and 0.5% not currently seeking employment or education. In an evaluation of recent STEM underrepresented graduates, it was reported that on average ~15% of undergraduates entered a professional degree program between 2017 and 2019 [28].

## 2.6. Limitations

This manuscript presents data on a small sample size, namely the number of students who are currently enrolled or have graduated within the past 5 years from our undergraduate program. We are further limited as there are not many similar programs who have written or published data related to their outcomes which we could use to mitigate our lower number with the comparative strength of a larger number. In an attempt to boost the strength of our numbers, we reached out to 7 universities offering similar programs to request data related to their recent graduating undergraduates. Two responded and unfortunately, the data supplied was not applicable to our population. In general, qualitative research by nature tends to have a smaller sample size, and thus is not generalizable. By using a mixed methods approach of both qualitative and quantitative data we can supply descriptive findings into context of our smaller sample size. It can be difficult to generalize findings presented from this descriptive review of the PUP program to other similar populations and/or programs. The choice of a descriptive study design additionally makes it difficult to use experimental controls, as it would be difficult to determine whether the results are due to the variables being studied or to some other confounding factor.

## 3. Conclusion

While PUP is a new undergraduate program at USC's School of Pharmacy, it has demonstrated potential at preparing students for careers in the pharmaceutical industry and/or graduate education. The undergraduate degrees have been tailored to supply students both practical and theoretical skills that allows them to be successful in a variety of future career paths. The need for quality students will continue to grow within healthcare fields, and the novel structure of PUP is poised to address that need. Increased interest in a profession within the ever-expanding pharmaceutical field will also add to the student enrollments. We have an ambitious goal of a projected 500 students enrolled in one of our four pharmacy undergraduate degree offerings by 2025. We further expect graduating 100 students annually by 2026. The number of faculty members who actively teach in PUP may be small in comparison with the humanities or basic sciences, but USC's School of Pharmacy has ranked in the top 10% of pharmaceutical science teaching schools [36] and we anticipate concurrent growth of our faculty ranks as our number of enrolled undergraduate students grows to continue providing the most cutting edge and relevant curriculum for the students in PUP. These preliminary data are promising, and we have developed an iterative model of review, enhancement, and observation of course content and materials into our teaching model. This will allow us to make real-time adjustments to our program to keep our curriculum current and relevant with the demands of Pharmacy education. The annual survey of our graduated students will continue to include questions related to educational experience and we will mindfully incorporate necessary changes to keep the curriculum relevant to the needs of our students. PUP has been successful in getting students into graduate degree programs related to pharmaceutical sciences and medicine. A part of this success can be attributed to the dynamic nature of the course offerings and the creativity of the teaching faculty. PUP provides essential foundational knowledge that will lead to new opportunities in careers in the biomedical industry, life sciences, nutrition and food sciences, diagnostics, policy, drugs, and medical devices. PUP students leave their undergraduate program with practical and theoretical skills to aid them in their future careers. PUP continues to be a dynamic undergraduate degree program and has expanded the footprint of pharmacy education into undergraduate studies at USC. This manuscript is the starting point for further inquiries into the quality, effectiveness, and sustainability of the PUP program.

## Author contribution statement

Terry David Church: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Amanda M Burkhardt; Tam Phan: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Daryl L. Davies: Analyzed and interpreted the data; Wrote the paper.

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## Data availability statement

Data included in article/supp. material/referenced in article.

## Declaration of interest's statement

The authors declare no competing interests.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e13437>.

## References

- [1] D.H. Rhoney, S. Singleton, N.R. Nelson, S.M. Anderson, R. Hubal, Forces driving change in pharmacy education: opportunities to take academic, social, technological, economic, and political into the future, *JACCP* 4 (5) (2021) 639–651.
- [2] D.L. Brown, Years of rampant expansion have imposed Darwinian survival-of-the-fittest conditions on US pharmacy schools, *Am. J. Pharmaceut. Educ.* 84 (10) (2020) 1277–1281.
- [3] N. Pavuluri, R.R. Aparasu, K.M. Boje, et al., Consideration of aggressive and strategic approaches to address declining enrollment in US pharmacy schools, *Am. J. Pharmaceut. Educ.* 83 (6) (2019).
- [4] J.L. Hall, R.L. Corelli, R. DeHart, et al., Trends in pharmacy college admission test requirements and utilization across colleges and schools of pharmacy, *Am. J. Pharmaceut. Educ.* 85 (3) (2021) 1–6.
- [5] M.A. Chisholm-Burns, P. Berg-Poppe, C.A. Spivey, J. Karges-Brown, A. Pithan, Resilience and first-year pharmacy students' academic performance in a pharmacy math course, *Am. J. Pharmaceut. Educ.* 85 (8) (2021).
- [6] W.B. Call, G.R. Grice, K.B. Teller, A.L. Armbruster, A.M. Spurlock, T.M. Berry, Predictors of student failure or poor performance on advanced pharmacy practice experiences, *Am. J. Pharmaceut. Educ.* 84 (10) (2020) 1–8.
- [7] C. Pizarik, T. Whelchel, Academic relevance: college students' perspective, *Int. Teach. High Educ.* 30 (1) (2018) 26–35.
- [8] M.K. Cor, D.R. Brocks, Examining the relationship between prerequisite grades and types of academic performance in pharmacy school, *Curr. Pharm. Teach. Learn.* 10 (6) (2018) 695–700.
- [9] B. Sepodes, J.P. Rocha, M.-E. Figueira, Adapting education to the needs of pharmacists and pharmaceutical scientists, in: I.V. Figueiredo, A.M. Cavaco (Eds.), *Pedagogies for Pharmacy Curricula*, IGI Global, 2021, pp. 20–42, chap. 2.
- [10] S.B. Vincent, W. Marsh, M. Goodwin, J. Farr, Impact of providing a living learning community for first-year pre-pharmacy students, *Am. J. Pharmaceut. Educ.* 85 (1) (2021) 23–27.
- [11] C. John, The changing role of the pharmacist in the 21st century, *Pharm. J.* 300 (7909) (2018) 1.
- [12] L. Lebovitz, M. Rudolph, Update on pharmacist workforce data and thoughts on how to manage the oversupply, *Am. J. Pharm. Educ.* 84 (10) (2020) 1–3.
- [13] L. Lebovitz, N.D. Eddington, Trends in the pharmacist workforce and pharmacy education, *Am. J. Pharm. Educ.* 83 (1) (2019) 4–11.
- [14] D.L. Brown, It is time to rethink the all-Pharm. D. educational system: multiple tiered degrees would better serve the diverse nature of pharmacy practice, *JACCP* 3 (6) (2020) 1147–1154.
- [15] N. Schmitz, L. Richert, Pharmacists and the future of cannabis medicine, *J. Am. Pharm. Assoc.* 60 (1) (2020) 207–211.
- [16] C. Nguyen, The role of a pharmacist as a medical information specialist in the pharmaceutical industry, *Curr. Pharm. Teach. Learn.* 12 (2) (2020) 127–131.
- [17] Z.-U.-D. Babar, A. Birna Almarsdóttir, The future of pharmacy practice research, in: B. Zaheer-Ud-Din (Ed.), *Pharmacy Practice Research Methods*, second ed., Springer Nature, 2020, pp. 251–265.
- [18] V. Papadopoulos, D. Goldman, C. Wang, M. Keller, S. Chen, Looking ahead to 2030: survey of evolving needs in pharmacy education, *Pharmacy* 9 (1) (2021) 59–67.
- [19] A.S. Jarab, W. Al-Qerem, T.L. Mukattash, Career choices of Pharmacy and Pharm D undergraduates: attitudes and preferences, *Heliyon* 7 (3) (2021), 1, 8.
- [20] B. Jacob, S.K. Peasah, An elective course for student pharmacists on pharmaceutical industry practice, *Am. J. Pharm. Educ.* 83 (8) (2019) 7307.
- [21] ACPE, Guidance for the Accreditation Standards and Key Elements for the Professional Program in Pharmacy Leading to the Doctor of Pharmacy Degree, Accreditation Council for Pharmacy Education, Chicago, IL, 2015, pp. 1–45.
- [22] ACPE, Accreditation Standards and Key Elements for the Professional Program in Pharmacy Leading to the Doctor of Pharmacy Degree, Accreditation Council for Pharmacy Education, Chicago, IL, 2015, pp. 1–39.
- [23] H.D. Berlie, K.K. Janke, C.L. Garwood, Cultivating a vibrant and thriving elective curriculum in pharmacy schools, *Am. J. Pharmaceut. Educ.* 84 (4) (2020) 410–414.
- [24] H. Nazar, A. Rathbone, A. Husband, The development of undergraduate pharmacy students as reflective thinkers for the evolving field of pharmacy, *Int. J. Pharm. Pract.* (2021) 1–6. Advance Access Publication, <https://academic.oup.com/ijpp/advance-article-abstract/doi/10.1093/ijpp/riab005/6211077> [accessed 4 May 2021].
- [25] A. Assaroudi, F. Heshmati Nabavi, M.R. Armat, A. Ebadi, M. Vaismoradi, Directed qualitative content analysis: the description and elaboration of its underpinning methods and data analysis process, *J. Res. Nurs.* 23 (1) (2018) 42–55.
- [26] A.-S. Pietsch, S. Lessmann, Topic modeling for analyzing open-ended survey responses, *J. Bus. Anal.* 1 (2) (2018) 93–116.
- [27] R.B. Johnson, L. Christensen, Methods of data collection in quantitative, qualitative, and mixed research, in: R.B. Johnson, L. Christensen (Eds.), *Educational Research: Quantitative, Qualitative, and Mixed Approaches*, seventh ed., Sage publications, 2019, pp. 179–206.
- [28] USC, Spring 2021 Enrollment Report, USC: Office of Institutional Research, 2021, pp. 1–79.
- [29] USC, Facts and figures, Accessed 27 May 2021, <https://about.usc.edu/facts/>.
- [30] C.R. Ford, E.L. Kleppinger, C.C. Cheatham, et al., Identifying future pharmacists: development and implementation of a pharmacy camp experience, *Curr. Pharm. Teach. Learn.* 12 (4) (2020) 400–409.
- [31] N. Morningstar-Kywi, R.E. Kim, Using interactive fiction to teach clinical Decision-making in a PharmD curriculum, *Med. Sci. Educ.* (2021) 1–9, <https://doi.org/10.1007/s40670-021-01245-7>. On Line [Accessed on 1 March 2021].
- [32] J.H. Oestreich, J.W. Guy, Game-based learning in pharmacy education, *Pharmacy* 10 (1) (2022) 1–11.



- [33] R.G. Baldwin, The climate for undergraduate teaching and learning in STEM fields, *N. Dir. Teach. Learn.* 2009 (117) (2009) 9–17.
- [34] J.C. Bennett, L. Lattuca, K. Reed, T. York, Strengthening Pathways to Faculty Careers in STEM: Recommendations for Systemic Change to Support Underrepresented Groups, 2020.
- [35] USC., USC undergraduate post-graduation plans, Accessed 1 Dec 2022, <https://aftergradoutcomes.usc.edu/>.
- [36] USNEWS.COM. Best Pharmacy Schools. Y - 2021.