INSTRUCTIONAL DESIGN AND ASSESSMENT

The “Research Track” Concentration, a New PharmD Elective Option

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Objectives. To enhance student curricular satisfaction, position students for multiple career options, and counter the national deficit in pharmacy faculty members by creating a research elective for students enrolled in a first-professional degree PharmD program.

Design. The research track consists of 12 credit hours of didactic, seminar, and research courses. This concentration option entails graduate-level coursework and 2 consecutive semesters of attending a graduate seminar course and conducting independent but faculty-mentored basic science or pharmacy administration research.

Assessment. Current PharmD students and recent PharmD graduates provided feedback on their experience via e-mail, telephone or in person.

Conclusion. In its second year of existence, the Duquesne University pharmaceutical sciences research track option has been positively received by PharmD students, has successfully directed PharmD students toward research-based careers, and may serve as a template for similar concentrations at other colleges and schools of pharmacy.

Keywords: research, elective, concentration, doctor of pharmacy

INTRODUCTION

As regularly acknowledged by the leaders of the American Association of Colleges of Pharmacy, pharmacy colleges and schools have an obligation to stay abreast of cutting-edge pharmaceutical research via the novel research efforts of their faculty members and the independent research efforts of their students. Maintenance of a vigorous research program is critical to recruiting, developing, and retaining well-qualified faculty members and preparing the next generation of PharmD graduates for the increasingly complex field of pharmaceutical care. While most US pharmacy colleges and schools required PharmD students to engage in research-based coursework in 1999, less than 13% of schools surveyed required a project involving data collection, analysis, and a summative report. Indeed, research as a curricular requirement is not always viewed favorably by PharmD students. Research courses as PharmD electives, on the other hand, were found to be more palatable to the student.

While the average PharmD student may not recognize the value of a curricular research option, PharmD graduates do appear to view research experience as a priority. Of over 400 University of Michigan PharmD graduate survey respondents, 82% stated that the required research project should be continued, and that exposure to research translated into job market flexibility and adaptability, increased job satisfaction, and increased career achievement. Alumni survey data indicate that PharmD graduates with undergraduate research experience report greater enhancement of cognitive and personal skills, an especial satisfaction with their undergraduate education, and a greater likelihood of continuing their education.

Toward the goals of enhancing PharmD student curricular satisfaction, positioning the student for multiple career options, and countering the national deficit in pharmacy faculty numbers, a novel PharmD research concentration recently introduced to the Duquesne University School of Pharmacy (DUSOP) curriculum is described. While an independent research component is often offered or required by a typical PharmD curriculum, the literature on established research concentrations is sparse. The University of Maryland “research pathway” requires completion of 28 didactic and experiential credit hours, a more time-intensive version of the concentration described here. Another version of the research track requires that PharmD students select this option in the second professional year, an earlier start than required by the DUSOP. The research concentration described is not suggested to be superior to versions existing elsewhere, but rather most conducive to the DUSOP curriculum.
DESIGN

Expected Outcomes

Using the research track concentration elective option, students seeking an intellectual challenge will augment their course-based knowledge of the pharmaceutical sciences via an independent research project. By applying this knowledge to a testable hypothesis, experiments will be designed, conducted, analyzed, and interpreted by the student in collaboration with the faculty research mentor. The student will generate novel research findings for communication at national meetings and publication in peer-reviewed journals. In the process, the student will learn what a research career entails and whether he or she has aptitude for or is inclined toward an academic or industrial pharmacy career. The student will gain experience (as well as credentials in the form of the certificate) that should facilitate entry into an appropriate research appointment or graduate school.

Educational Environment

Of the nearly 550 PharmD students in the DUSOP professional curriculum, approximately 20 are involved in basic or clinical research at any one time. Surprisingly, only 1 or 2 students per year typically display the initiative to attain the BS in Pharmaceutical Sciences as a second degree, even though 100 hours of independent research and a regional/national meeting presentation are the only requirements beyond the student’s normal curriculum. The fact that only 2%-4% of our students are exposed to research is, in the opinion of the authors, due to 3 factors: (1) with an already rigorous curriculum, there is little incentive to take on such a demanding “extracurricular” activity; (2) the students are not aware that conducting basic or clinical research is an option, and most have no idea what research entails; (3) the option of community-based, retail pharmacy is currently financially lucrative. Thus, a career in research may not be seriously considered.

To provide an incentive for pharmacy students to venture into research, the authors initiated a DUSOP “research track” that was officially recognized as a PharmD curricular component in May 2003. This track constitutes a “concentration” or “major” for the pharmacy student, and complements the existing geriatric pharmacy and pharmacy management tracks. Upon completion of the requirements for this concentration, the student receives a certificate that is recognized at graduation, providing a research credential that may be useful for entry into a graduate program. The research track, described more thoroughly below, requires independent research for 2 consecutive semesters, participation in weekly departmental research seminars, and didactic credit hours from graduate-level courses.

The second factor hindering pharmacy student participation in research, ignorance of research as an option, has been addressed by presenting an on-campus poster session during the fall semester organized by one of the authors. Almost all researchers in the DUSOP are represented, and many laboratories in the chemistry, biochemistry, and biology departments also participate. All 4 disciplines are housed in the same building, and are available to the student in satisfying the requirements for the research track. All second-professional year students are required to attend this poster session. This mechanism serves as an effective recruiting tool for the research track and BS degree programs.

The third factor presumably not conducive to PharmD students considering a research career, financial incentives that accompany conventional pharmacy graduate opportunities, would appear to be the hardest to combat. Nevertheless, some of our best students routinely voice their disenchantment with the conventional career routes after starting their advanced clerkship experiential education courses. Such traditional experiential rotations do not provide the PharmD student an opportunity to understand the nature of a career in academic pharmacy. Because our top 100 students have an average SAT score above 1200 and have the intellectual potential to be top-flight researchers, it is appropriate that these students have the opportunity to explore basic or clinical research as an educational opportunity and a career option. If sufficiently intrigued by the research experience, it is realistic to expect that a larger number of these students will opt for a pharmaceutical sciences-based graduate program within 5 years of graduation, instead of choosing a typical post-PharmD educational alternative such as a business or law degree. Even now, some DUSOP graduate students find that post-PharmD education and pharmacy practice are not mutually exclusive in that their weekend pharmacy position provides more income than their annual stipend.

Content

The research track concentration is comprised of didactic, independent research, and seminar components. Separate versions of this elective option that vary in the percentage of each component were designed for the pharmaceutical science and pharmaceutical administration subdisciplines, and the required 12 credit hours for these subdisciplines were respectively divided by 6:4:2 and 9:2:1 ratios. The weighting of the 3 components differed primarily because the laboratory experimentation of pharmaceutical scientific research typically requires a larger time investment to complete the undergraduate research project.
**Didactic component.** The didactic credits are satisfied by completing graduate-level courses, selected in consultation with the student's mentor (professor serving as Research Director) to complement the research experience. Students pursuing the certificate in the Division of Pharmaceutical Sciences typically choose courses from the 3 divisional departments: Pharmaceutics, Pharmacology and Toxicology, and Medicinal Chemistry. Some of the graduate courses that students working in a pharmaceutics laboratory may choose are Advanced Pharmaceutics, Manufacturing Pharmacy, Pharmaceutical Formulation and Development, Regulatory Aspects of Industrial Practice, Data Analysis and Modeling, Chemometrics, and Cosmetic Science and Technology. Among the selections for pharmacology/toxicology students are Drug Mechanisms, Methods of Evaluation of Drug Action, General Toxicology, Clinical Toxicology, Forensic Toxicology, Pathology, and Neuronal Biochemistry. Students with a medicinal chemistry focus are offered choices that include Advanced Medicinal Chemistry, Selected Topics in Medicinal Chemistry, and Spectral Methods. In fall 2004, a new course, Principles of Drug Action, Design and Delivery, was added to provide a graduate-level overview of the pharmaceutical sciences and is likely to be a popular choice for research-track PharmD students. Students are also at liberty to choose from graduate courses in the chemistry, biochemistry, or biology departments if appropriate for their research project and approved by the research mentor.

Students may also conduct independent research in pharmaceutical administration. Active projects include studying the impact of direct-to-consumer prescription drug advertising, patient preferences for pharmacy benefits under a managed care plan, and the use of internet technologies as assessment methods. Graduate courses include Health Care Economics, Marketing/Customer Service, Managed Care Principles and Policies, Social and Behavioral Aspects of Pharmacy, and Educational Statistics.

The research-track student may enroll in these courses during any curricular year; however, satisfying the didactic requirement of the concentration during the final (fourth professional) year of the PharmD curriculum, a year reserved for elective courses and experiential education courses, is most feasible. Because some of the 5-week advanced clerkship experiential courses are off campus, the students cannot always conform to the graduate course schedule. One didactic course, not to exceed 3 credit hours, may therefore be selected from the available existing PharmD elective choices. This course choice is subject to the approval of the research mentor and the division head, who seek to ensure that the course approximates one at the graduate level. The DUSOP makes every effort to schedule experiential rotation blocks of fourth-professional year PharmD students around the didactic courses. For all courses, the PharmD student is generally held to the same standard as a first-year master’s or doctoral graduate student with respect to assignments, class participation, and grading.

**Independent research component.** Each research credit hour will be equivalent to 4 to 5 hours of independent work (eg, actual laboratory bench work) per week for one semester (or the same number of total hours distributed over a summer). Two credit hours must be achieved in each of 2 consecutive semesters (or a consecutive semester and summer). The student is encouraged to complete the research component prior to the fourth-professional year; thus, the spring semester of the third-professional year and the following summer is a popular option. The student will function much like a first-year graduate student, carrying out a well-defined research project, periodically meeting with the research mentor, and independently collecting data. Optimally, the student will have his or her own project, but collaboration with a senior graduate student is also an option. In all cases, the research mentor, senior graduate students, or both are expected to provide guidance in the methodology. The student will participate whenever possible in research group meetings, presenting his or her latest data, offering plausible interpretations of the data, and brainstorming with the group to “troubleshoot” any problems encountered during the week. The student will conduct statistical analyses of data and any other necessary analyses (eg, nonlinear regression analysis of radioligand receptor binding assays) to render the data in an understandable, and perhaps publishable, form. The student is expected to behave as a responsible, reliable team member, as opposed to treating the experience as a “hobby” or “diversion.”

**Seminar component.** Each seminar credit hour corresponds to attendance at and participation in the weekly departmental seminar series appropriate for the student’s research group, including a formal presentation of a caliber consistent with that of a first-year graduate student. When scheduling precludes student attendance at the departmental seminar, the student will be expected to attend and participate in weekly research meetings of the student’s group held by the research director. This option is typically exercised while the student is completing part of the research component during a summer; in fact, the seminar component is usually completed in parallel with the research component, and prior to the final year.

**A sample PharmD research project.** A faculty mentor must provide projects and laboratory experiences that are conducive to PharmD student research. Matching
students with appropriate research projects is not a trivial exercise when one is trying to maintain both student interest and productivity; either overwhelming or underwhelming a student with a given project can demoralize a student to the point that a career involving research is no longer seriously considered. The student’s interest and competence in the work must be monitored to ensure that he or she is appropriately challenged. The student should have an opportunity to master several research techniques in a logical sequence that furthers the goals of the research director. As an example, under the mentorship of one of the authors (and occasionally that of a senior graduate student in the laboratory), one DUSOP PharmD student completed a project involving mutagenesis and characterization of a G protein-coupled receptor. The student became proficient in several molecular pharmacology techniques in only 2 semesters and, more importantly, determined whether this was a career option for him.

In the course of the project, the student transformed bacterial cells with a plasmid cDNA encoding a wildtype melatonin receptor. The student prepared antibiotic-resistant agar plates, inoculated growth media with antibiotic-resistant transformant colonies from these plates, and isolated the amplified plasmid via ion-exchange chromatography. This plasmid served as a template for polymerase chain reaction (PCR)-based site-directed mutagenesis, and the student was involved in the design of the mutagenic oligonucleotides. The student synthesized and purified the mutant PCR product with agarose gel electrophoresis and subsequent size-exclusion chromatography, used appropriate restriction enzymes to digest the product, and subcloned the product into a “pharmacology-friendly” plasmid. After selecting for colonies containing bona fide mutant cDNAs and verifying via DNA sequencing, the student amplified and purified the mutant receptor cDNA and transfected a mammalian cell line with this plasmid. The student assessed the ligand binding and signaling ability of the mutant receptor in the transfected mammalian cells via radioligand binding and other pharmacologic assays. The student analyzed receptor binding/activation results with appropriate software and recorded data and results in his laboratory notebook. The student presented findings to the rest of the research group, and participated in the discussion regarding significance and future directions. Although not a requirement of the research track, the student elected to present his findings in poster form at a regional scientific conference, which rendered him eligible for the BS in Pharmaceutical Sciences degree as well. This PharmD student researcher thus acquired experience in molecular biology, biochemistry, immunocytochemistry, and pharmacology in only 2 semesters. These skills are not exclusive to the field of molecular pharmacology and can be applied in graduate programs in almost all of the biomedical sciences.

ASSESSMENT
Assessment Population and Methods
Eighteen current PharmD students and recent PharmD graduates were asked via e-mail to reflect on what they derived from their research experience while at Duquesne University, and whether the new research track helped, or would have helped, in deciding on a career. Positive, negative, and neutral comments were solicited, and students were given the option of replying to the authors by e-mail or in person, or submitting responses anonymously. No respondents chose to remain anonymous. Three of the respondents were graduates who had completed the research concentration certificate requirements, and 2 more were slated to receive the certificate in the near future; of the remaining 13 students contacted, 5 had graduated before the research track was in place, 4 chose not to pursue the certificate, and 4 were still undecided. Fifteen of the 18 students responded, including 4 of the 5 research track students/graduates. Of the 15, 6 had graduated, 2 were fourth-professional year students, 3 were third-professional year students, 3 were second-professional year students, and 1 was a first-professional year student; 2 had a BS degree or equivalent, and none of the remaining 13 divulged any prepharmacy research experience. Of the 15, 3 were in the pharmacy administration division and 12 were in the pharmaceutical sciences division. Of the latter 12 students, 7 were in the pharmaceutics, 3 were in the medicinal chemistry, and 3 were in the pharmacology/toxicology subdisciplines.

PharmD Feedback on the Research Experience
Selected comments from the 4 research-track respondents indicated that the research experience was positive, and a professional asset:

- “The research track definitely helped me to decide to stay at Duquesne to pursue graduate work and become involved in social and administrative science research.”
- “I felt that the research track was a very good introduction to what one would face if they were to pursue graduate studies and/or a career involving research.”
- “I felt the research concentration was a tremendous experience to see what else is out there besides retail, which the PharmD curriculum is driven towards. It definitely sparked an interest in research which I hope to continue in the career path I choose. I am glad the research
A graduate student who received the PharmD degree the year before this certificate was awarded commented, “The research track came too late for me to participate in it, but I definitely think that it does open new opportunities for the undergraduate. . . . I know many of my fellow graduates wished that they had looked into other areas in which they could have practiced pharmacy (ie, graduate work, research, or even teaching).”

First-, second-, and third-professional year students participating in independent research, but who had not decided whether to commit to the research track, also found that the experience provided a better understanding of their career options:

- “[I] hope to go to graduate school after pharmacy school and pursue a career in research. . . . I think this [research experience] has definitely shaped my career path.”
- “… doing research showed me a completely new side of pharmacy as a profession.”
- “My goal was to find out what research was about, and I did.”

Two students found that they were interested in research, but not basic science research. These comments centered on a need for a career with more interpersonal interactions than they associated with “bench science”:

- “Because I would like to enter academia, research did guide me into looking into several graduate schools for pharmaceutical research. However, with time I realized that a more clinical path is right for me.”
- “I figured out that I really need to have more human interaction in the course of my day, and that by working in a clinical setting, I am able to get more immediate gratification and satisfaction. This revelation came at a good time because then I was able to look into different types of clinical research that may be more appealing to me. In fact this year I chose two rotations that are more clinical research-based, one at the Pittsburgh Cancer Institute and one at NIH.”

There was also a student whose research experience allowed him to rule out a research-based career: “I wanted to impact people’s lives through research, but I found it was much more satisfying for me to impact people’s lives as a pharmacist (intern) through my [retail] internship. Having the experiences in research and as a [retail pharmacy] intern allowed me to decide [between the two].”

Contrasting with the experience of at least one other pharmacy school, one clear and surprising trend that emerged from the Duquesne student feedback was that the earlier the PharmD student joined a research program, the less likely they were to choose the research track or pharmaceutical research as a career option. This included students who initiated their research project in the second or third academic year (preprofessional or first-professional year) of the “0-6” program. These students offered several reasons for this apparent paradox. First, and most obvious, was the time constraint. Most pre-professional and first-professional year students seem overwhelmed by the curriculum, let alone adding several research hours to their week. The problem was compounded by the tendency of these younger students to spend an inordinate amount of time on independent research, perhaps 20 hours or more per week, instead of the more reasonable 3-10 hours per week for a neophyte. The zeal to do something new and potentially world-changing, while also striving to impress a professor they greatly respect were reasons they gave for this overcommitment to research. Additionally taking into account that 2 of these junior students admitted to having poor time management skills, conducting research became a luxury these students could no longer afford: “I think that maybe a class or retreat or workshop to teach time management skills would have benefited me earlier in my research experience.”

Without the goals of authorships on research articles or imminent graduate degrees to obtain, these students probably could not generate the motivation to log so many research hours per week. Six students cited feelings of inadequacy as a researcher. Four statements were made along this line:

- “I think I would have liked my research more and stuck with it had I understood more about the topics.”
- “It was hard for me to understand the big picture of the research I was doing.”
- “I felt that I needed general lab classes, ie, how to keep a lab notebook…”
- “I needed a formal class on in depth . . . theory [regarding the research subject].”

These frustrations and the heavy workload led 2 of these students to cite “burnout” as a reason for discontinuing the research; neither of these students possessed the BS degree or any research experience prior to pharmacy school. They felt a research career was still an option, but their research experience occurred at a time too early to be contemplating career decisions. One student admitted that he dwelt on how his friends were enjoying the spring weather outdoors while he was anchored to the laboratory bench.
In contrast, PharmD students whose research experience began in the spring semester of the second-professional year or the fall semester of the third-professional year were more likely to seriously consider a career that included independent research and the research track. It is probably no coincidence that the academic rigors of the PharmD program become markedly more manageable upon reaching the spring of the second-professional year. With more time to work, improved time management skills, a better educational background to appreciate the research project, and the confidence that they were not about to “flunk out” of the PharmD program, this group presumably was in a position to enjoy and excel in independent research. These students also frequently commented that their interest in a research-based career rose with the discovery that the conventional avenues for a pharmacy career were not appealing to them, information that the preprofessional and first-year professional students did not yet have.

**Future Assessment of the Research Track Option**

Because the research track option is only in its second year, too few students have participated to definitively assess whether the program is achieving its goals. Three PharmDs have satisfied the requirements for the research track certificate to date. Two of the 3 are now MS and PhD graduate students at Duquesne University and George Washington University, respectively, and the third is a retail pharmacist. Once there are enough certificate recipients to render the results meaningful, an anonymous survey instrument will be used to assess the percentage of students who entered a graduate degree program, the percentage whose career involves research, and their perceptions on the relevance of the research track components and individual courses to a research-oriented career. The survey will include ratings of didactic instructors and research mentors, and will be published in a peer-reviewed education journal.

**CONCLUSION**

Duquesne University has designed a research concentration elective option that offers the PharmD student an accurate picture of what a career as a pharmaceutical researcher entails. At the same time, this research track permits the student enough flexibility to seriously entertain other career paths. Student feedback was very positive in that the experience typically allowed the student to determine whether a research career was an appealing option. As hoped, most (4 of 5) of the research track students were encouraged by the experience to embark on graduate education or research-based employment, or alter their course choices in that direction.

Undergraduate research experiences in a variety of fields have been shown to translate into pursuit of academic careers.14-16 Introducing the PharmD student to academic research has been recognized as a strategy for promoting interest in academic pharmacy.17,18 The DUSOP research-track will serve as a recruiting tool for graduate programs in the pharmaceutical sciences.

**REFERENCES**

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