RESEARCH

Pharmacognosy, a Classical Theme Tuned to a Contemporary Melody

Yan Zhang, PhD,^a Lisa B. Phipps, PharmD, PhD,^b Jennifer McDaniel, MSLS^c

^a Virginia Commonwealth University School of Pharmacy, Richmond, Virginia

^b Office of Learning Innovation & Student Success, Virginia Commonwealth University, Richmond, Virginia

^c Tompkins-McCaw Library for the Health Sciences, Virginia Commonwealth University, Richmond, Virginia

Submitted July 25, 2016; accepted April 24, 2017; published October 2017.

Objective. To describe the development of a pharmacognosy course that uses a combination of didactic teaching, team-based projects, and practicum laboratory practice.

Methods. A course titled “Pharmacognosy” was developed by applying a three-tier teaching methodology: in the classroom, the basic concepts and principles were introduced in a didactic manner; outside the classroom, students worked in teams and each team created an independent literature-based research project that was submitted as a poster presentation; in the pharmacy practicum laboratory, students worked individually and conducted a quality control experiment comprised of a quantitative analysis of an herbal product.

Results. During the seven-year course implementation, 1091 first-year PharmD students participated in the course. Their performance was consistently satisfactory. On average, 30% of students in each class received a grade of “A” and teams received a “B” and above on their projects.

Conclusion. The pharmacognosy course, equipped with concurrent teaching methods, implemented with a group research project, and reinforced by practicum laboratory experience, has reached the original goal of introducing a classical topic in an updated and contemporary fashion to meet the requirement of integrated pharmacy education and practice.

Keywords: pharmacognosy, pharmacy curriculum, complementary medicines, herbal medications, natural products

INTRODUCTION

Pharmacy practice has been evolving in the US over the past two decades. Among all the medications managed by practicing pharmacists, herbal medications (including alternative and complementary treatments) have attracted more attention from patients and their health care providers as consumer usage of these products continues to grow.¹ Concomitantly, the market value of herbal medications and alternative medicines has been growing dramatically in the past few decades.² However, there is a paucity of literature on the current role of pharmacognosy in the Doctor of Pharmacy (PharmD) curriculum in the US. While pharmacognosy as a component of pharmacist education has been a topic in the literature since 1947 as US pharmacy schools tried to reconcile how best to present it in their respective programs,³⁻⁶ there is little guidance and no consensus in the literature on this role in PharmD curricula. Articles discussing pharmacognosy

education in PharmD curricula include topics such as the state of complementary and alternative medicine (CAM) education at US pharmacy schools,⁷ the inclusion of pharmacognosy as a lecture topic in a broader credit course,⁸⁻¹⁰ perceptions of PharmD students regarding pharmacognosy,¹¹ active learning for pharmacognosy topics¹² and the evolution of a full-credit course in pharmacognosy in the PharmD curriculum at Northeast Ohio Medical University College of Pharmacy.¹³

In 2007, the Accreditation Council for Pharmacy Education (ACPE) released a set of standards and guidelines to reinforce the teaching of pharmacognosy and alternative and complementary treatments with specific curriculum topics for pharmacy schools as part of the science foundation for the PharmD curricula.¹⁴ It is imperative that these topics be taught in the PharmD curricula so as to prepare our students to be practice-ready. The curriculum committee at Virginia Commonwealth University (VCU) School of Pharmacy charged a subcommittee to create a new pharmacognosy course that will provide didactic and early experiential education for VCU's first-year PharmD students. The course was designed to fulfill the ACPE standards, prepare students for their clinical therapeutics courses and future practice,

Corresponding Author: Yan Zhang, Department of Medicinal Chemistry, School of Pharmacy, Virginia Commonwealth University, Suite 205, 800 East Leigh St., PO Box 980540, Richmond, VA 23298-0540. Tel: 804-828-0021 Fax: 804-828-7625. E-mail: yzhang2@vcu.edu

reflect current pharmacy practice, the connection between education and actual practice, and pharmacognosy's unique and rich history in pharmacy practice and the critical role it played in the evolution of modern Western medicine.

This article describes the design and content of the Pharmacognosy course, and presents the evaluation data on student performance and assessment from a seven-year implementation of the course.

METHODS

This paper has been reviewed by the Office of Research Subjects Protection at the Virginia Commonwealth University and has been determined that it does not require an IRB review and approval.

According to the ACPE standards (2006), within the domain of pharmaceutical sciences, the students should learn the concepts of crude drugs, semi-purified, and purified natural products.¹⁴ The students should also learn basic knowledge with respect to regulation of herbal products.¹⁴ The pharmacognosy course was designed to introduce basic concepts of pharmacognosy featuring many of the most important types of natural products and their impact on modern medical practice. The evaluations of alternative and complementary medicine purity and bioavailability were also discussed. We believe these topics satisfied the ACPE guidelines.

Course objectives were to enable students to describe the concepts of crude drugs, semi-purified, and purified natural products and learn the basic knowledge of the history of pharmacognosy and its impact on the modern medical sciences; explain the importance and challenges of herbal product regulations; recognize the chemical structures of natural products discussed in the course, their pharmacological activity and possible side effects, and further define the structure-activity-relationship of these natural products; explain the basic concepts and

principles of pharmacokinetics and fundamental application to herbal products, the evaluation of alternative and complementary medicine purity and bioavailability and its impact on their application; apply the principles of pharmacognosy to finish a case study on one type of natural product or herbal medication as a team.

We recommended four reference books for this course: "Fundamentals of Pharmacognosy and Phytotherapy," "Natural Products: A Case-based Approach for Health Care Professionals," "Pharmacognosy," and "Stockley's Herbal Medicines Interactions." These reference books were made available at the library from the beginning of the course for student use.

Lectures were given by faculty members from all three departments in the VCU School of Pharmacy and a pharmacognosy practitioner. They contributed teaching material based on their expertise in the field. The course consisted of 28 lecture hours, two mid-term examinations, and one final examination hour. The topics discussed during the lectures are shown in Table 1.

While designing the course, we found that one major challenge was covering the tremendous amount of information available on herbal medications and natural products involved in pharmacy practice within the two-credit-hour course schedule. We decided to tackle this by implementing a team-based project (6-7 students per team) instead of attempting to discuss all these medications/drugs in didactic lectures. The natural/herbal product case study poster project was a semester-long project. This project encouraged team building, reinforced essential knowledge principles and concepts by application, trained students to conduct literature searches and analysis, and build poster presentation skills. We believe that a team-based project of this nature will lead to stimulation of higher order thinking and problem solving.

The case studies on herbal or natural products and the resulting student-prepared posters served to strengthen

Table 1. Outline of the Contents in a Pharmacognosy Course

Course Subjects	Topics and Contents
Introduction	Basic concepts and history of pharmacognosy.
Herbal medications	Introduction on herbal medications, regulation of herbal products, evidence-based medicine, purity/content determination/evaluation of herbal products, herbal products pharmacokinetics and bioavailability, interactions between medications and herbal products.
Natural products	Introduction to natural products, natural products, including central nervous system, geriatric health, immunology, inflammatory diseases, infectious diseases, antiviral agents, cardiovascular system, endocrine system, cancer related agents, respiratory system, gastrointestinal system.

the students' knowledge of the basic concepts and principles of pharmacognosy. Activities to conduct the case study included topic selection, literature review, case design, literature data collection and analysis/discussion, and final poster preparation and presentation. Each team was asked to select one herbal medication, or a natural product, on the market with clinical usage or with acclaimed therapeutic benefits from literature, to conduct a literature search, to summarize and discuss the information/ knowledge related to one major application/usage of the target medication, and to present their research in poster format with defined size and related characteristics that simulate those of a formal scientific conference.

Before the course started, 20 teams were formed by random name assignment of all the students enrolled in the course. These group assignments were made known to the class at the outset of the course. A list of herbal medications and natural products as potential topics were also provided. Students were also encouraged to go outside this list to identify their own topic. A series of project deadlines were defined and relayed; credit toward the course's final grade was awarded for meeting these deadlines. Electing a team contact person (leader), defining the project topic, submitting the first and second draft of the project (in poster format), submitting the final version of the poster, and submitting the peer performance assessments within the group, were defined as goals.

The faculty members (course coordinator and instructors) provided guidelines and recommendations at each stage of the project. They also evaluated the final project posters that were printed and presented. Specific faculty input included: a seminar on how to conduct a literature search on herbal medications/natural products given by a pharmacy librarian from the university's health sciences library; a lecture on how to construct a research poster given by an experienced faculty member from the VCU Department of Pharmacology and Toxicology; review and approval of topics selected by each team; daily interactions between the course coordinator and each team to answer any general and/or specific questions; feedback on each team's draft poster provided by the instructors. The evaluation criteria of the final poster were made available at the beginning of the course so the students were aware of the goals. Each case study poster underwent a vigorous process of improvement and evaluation. This process included three submissions: the first draft submission was evaluated by the course coordinator with feedback to each group; the second draft submission was evaluated by the teams of volunteer faculty members, with their feedback summarized by the course coordinator and provided to each team; and the final submissions were printed, posted, and graded by the entire faculty team using the same detailed evaluation form.

We attempted to prevent student members of teams "coasting" through the assignment without making significant contribution by asking each team to distribute their duties evenly among all group members and asking each student to complete a peer performance review to evaluate his/her team members' performance during the project execution. The results of the review were counted in the final grades of the course. We assured that all students were aware of this expectation with periodic reminders that their performance and participation will directly influence their final course grade. Most students followed these recommendations and contributed eagerly to their team projects, as was clearly reflected in the peer review data.

To equip our students with practical knowledge of herbal medication quality control and quantity control, we adopted an herbal product quality analysis laboratory practice for the course, which was executed as an exercise in our Pharmacy Foundation Laboratory I course. This experiment familiarized the student with quantitative fluid measurement techniques and the use of a spectrophotometer to verify the dose of an herbal product formulation. Fluid measurement techniques and spectrophotometry are often used for quantitative analyses to evaluate purity, dose, dose uniformity, dissolution characteristics, chemical stability or other chemical characteristics. The United States Pharmacopeia and the Food and Drug Administration set guidelines on the acceptability of these quantitative results for drugs before they can be used to document the integrity of pharmaceutical products. However, herbal products are not subject to the same pre-marketing regulatory scrutiny as FDA-approved medications, and the route to the market place for natural products is much less tortuous: the Dietary Supplement Health and Education Act of 1994 permits herbs or phytochemicals to be sold as dietary supplements provided specific therapeutic claims are not specified on their labels. A statement may appear on the label to describe the product's role in affecting "structure or function in humans."

In the laboratory practice associated with the course, we asked the students to conduct basic analytic chemistry analysis to determine the amount of hypericin contained in one commercially available St. John's Wort product. The students conducted sample transfer, analyte extraction, purification, dilution, and measurement, and data collection and analysis in executing this experiment.

There were three components to the grading and assessment of the course activities the didactic lectures and their assessment contributed 80% of the final grade; evaluation of the poster preparation and presentation contributed 20% of the final grade; and the wet laboratory

practice was assessed in the Foundation Laboratory course. Course grades were assigned on the standard VCU scale: A=90-100, B=80-89.9, C=70-79.9, D=65-69.9, and F=0-64.9. For the first few years, we offered two written examinations (each contributing 40% to the final grade). In recent years, we have offered three examinations (with a concomitant change to 26.67% of the contribution of each exam to the final course grade) so that the students can study the lecture material in a more focused way.

The grading of the poster presentation was further divided into several portions: submitting the name of team's contact to the course coordinator (2%), submitting the topic of the project (3%), submitting two draft versions (2% and 3%) and the final version (5%) of the poster, the final evaluation by the faculty team (55%), and peer performance evaluations (30%). Student timeliness for their submissions was also evaluated as part of these grades.

We decided not to grade the wet laboratory practice based on students' performance in terms of quantitative analytical results. Instead, we asked the students to finish the laboratory exercise, collect and analyze data, summarize the data into a laboratory report, and respond to several questions related to the laboratory practice.

RESULTS

The outcome of the case study was successful. First, all groups finished the project with presentable posters. The teaching team review results (Table 2) reflect this fact very well. Students felt the pride of accomplishment when they stood in front of the final product, their printed posters. Many took pictures of themselves with the poster. All the posters were returned to the students for their own keeping.

Second, based on the formal course evaluation (Table 3) from the students, the poster project was well received starting from the first year it was offered. They

appreciated the opportunity to conduct this type of project, and many expressed an interest in participating in further research on these topics. The course coordinator adopted students' suggestions to further improve the process and strategy of the case study projects. For example, originally the peer review process within the group was not mandatory, but the students suggested the use of a graded peer review form for all group members. The adoption of this grading feature not only encouraged participation in peer review, but also helped reinforce team spirit and collaboration.

Third, the students' performance in the course was well-balanced between written examination scores and team-based project evaluations. The required knowledge of the course was thus shown to be comprehended in both theoretical and practical fashions. In the course's didactic portion, many students struggled with natural products-related material due to the complexity of the chemical structures and the largely under-defined mechanisms of action for each type. This was more or less reflected by the exam grades on this material. In their poster projects, however, many groups worked diligently and conducted extensive literature search on their topics, and were thus able to present in a comprehensive but specific way that proved that they knew and understood their poster topic.

Fourth, the students benefited from the hands-on experience and direct exposure to literature research. The methodology and experience they obtained from this experience will help them enrich and update their knowledge in this area for many years to come in their future careers. We all understand as pharmacy educators that the knowledge that we can introduce to our students during their degree studies is definitely limited. Many novel medications are introduced each year to the market and to clinical settings. Our pharmacists-to-be will have to face the challenges down the road to comprehend these new medications, but we believe that through this poster project our students were better prepared for literature

Table 2. Grade Distribution of the Course (2009 through 2015) in a Pharmacognosy Course

		Number of Students Who Received a Grade of:				Average Grade of Team Project (out of a total of 100 points)
		"A"	"B"	"C"	"D"	
Spring 2009	127	27	64	33	3	93
Spring 2010	129	82	47	0	0	94
Fall 2010	136	48	65	23	0	90
Fall 2011	140	45	82	13	0	90
Fall 2012	139	27	79	31	2	92
Fall 2013	137	60	63	14	0	93
Fall 2014	140	67	61	12	0	88
Fall 2015	138	42	77	19	0	92

Table 3. Selected Questionnaire Results on Course Performance by Students From 2010 Through 2015 in a Pharmacognosy Course (Mean Values of Each Class Response)

No.	Question	Spring 2010 N=129	Fall 2011 N=136	Fall 2012 N=139	Fall 2013 N=137	Fall 2014 N=140	Fall 2015 N=138
1	This course stimulated my thinking.	3.2	3.3	3.5	3.5	3.5	3.7
2	The course material was challenging.	3.3	3.5	3.8	3.5	3.5	3.7
3	I felt motivated to learn in this course.	3.1	3.2	3.4	3.4	3.4	3.6
4	Instructional methods used facilitated my learning.	3.0	3.1	3.3	3.3	3.4	3.5
5	Course assignment complexity and length were reasonable.	3.0	3.3	3.4	3.3	3.4	3.6
6	Exams were reasonable in length and difficulty.	3.2	3.1	3.3	3.4	3.4	3.6
7	The course integrated well with other courses.	3.2	3.3	3.4	3.4	3.4	3.6
8	The practical application of subject matter was apparent.	3.2	3.4	3.5	3.5	3.4	3.6

Point value: 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree

searches and self-education, and therefore, better prepared for their future.

Fifth, the faculty team also benefited as they offered guidance and participated in discussions with the student teams. This enriched their understanding of the material through observation and evaluation of the projects. Faculty members confirmed that they learned a lot from the students during discussions of the poster projects and final evaluation process. We all felt obliged to improve our teaching and lecture materials so that we would not fall behind our students in relevant topics.

The laboratory was offered as part of the course and provided a good opportunity for students to understand the importance of quality and quantity control of herbal medication and their potential problems/challenges. Although we did not grade the students on their practical performance and final data sheet summary, all students finished the laboratory successfully and, as indicated by the post-experiment quiz results, understood the concepts and basis of the exercise.

The course grades have been encouraging even from the first offering of this course. For the past six years we have offered the course seven times to the P1 classes. About 30% of students received a grade of "A," about 50% received a "B," 15% got a "C," and a small percentage received a "D." Overall, the grade distribution showed as a skewed bell shape, which is common in our PharmD curriculum courses. Evaluating each component of the final grade, apparently the contribution (20%) from the team project boosted the overall grade significantly. This was not unexpected as team grades often tend to be higher than individual grades, and, unlike exams, students can devote as much time to this project as they wish. There was a general downward trend grade-wise in the team projects over the past seven years (Table 2) although overall, all the teams did very well. One reason could be that

the teaching team's evaluation standard was intuitively on a rising slope.

We conducted anonymous student course evaluations each year. First in paper then with a computer-based instrument. The student evaluations from all past years have been very positive (Table 3). Overall, for each evaluation question on the course, the scores improved significantly over time. In particular, more and more students felt that they were motivated to study in this course. Most of the students also recognized the course coordinator's effort in improving the course material and exam. More importantly, the students appreciated the practical application potential of the course for their future career.

DISCUSSION

The topics covered in the didactic teaching were formulated based on the ACPE guidelines and the expertise of our faculty team in their respective research areas. The lectures can be divided into two parts. The first part was mainly the discussion of the basic concept of pharmacognosy, current herbal medication practice and regulation. The second part was focused on the introduction of different types of natural products and discussion of their potential applications. Such an arrangement not only satisfies ACPE requirements for the pharmacy curriculum, but also provides basic knowledge for our students to build a strong foundation for studying future therapeutics topics.

The majority of our P1 students did not have previous direct experience with poster presentations, no more than one-third of them had previous research exposure, and most of them had never worked in a team-based environment. Thus, we had the additional challenges of bringing them all up to the same or similar level with respect to quality literature research and preparing and presenting research posters.

The benefits of these case studies include opportunities for building team spirit, reinforcement of essential principles and concepts of the course by their application, training in literature search and analysis, exploration of research philosophy, and building technical skills in poster preparation and presentation. For example, to prepare and finish the project, students had to cooperate with each other, coordinate their study schedules, and compromise to solve conflict among themselves. These kinds of activities help build effective team spirit. Also significant is that many students self-reported that working on such a project enabled them to practically apply the knowledge they learned from didactic teaching into the higher level skills of data interpretation related to their poster project. Most of the students also reported that this was their first time presenting a scientific poster and that they cherished the opportunity and felt this would be beneficial to their future careers.

We have been continuously and consistently working to improve the course over the past six years. For example, the original examination plan was based on the material itself, ie, one written examination for herbal medication focused topics and one for natural product related topics. However, after students expressed their concerns regarding the complexity and difficulty of the natural product topics, their suggestion to split that material into two examinations was implemented. Although it was not common to have three examinations for a two-credit course, we adopted this suggestion because in recent years, few PharmD students admitted into the program have a chemistry-related degree and the natural product related topics heavily rely on organic chemistry knowledge. Offering the additional examination gave students more time to digest the knowledge, and helped us to achieve our teaching goals. The adjustment showed a positive effect immediately: the students felt that they had more focused study time and the examinations were not as demanding compared to the ones in the past.

The limitations of this pharmacognosy course include constrained timeline of the course to follow up with the latest progress in the field, difficulties to cover a tremendous amount of information on herbal medications and natural products available and applied in practice.

In the future, we plan to continue modifying the course's operation and organization to help students to learn the material more efficiently. We will also adjust the lecture and related material based on emerging new herbal products on the market, and add more natural products related to new FDA-approved drugs. We may adjust the teaching team by asking more industrial experts to come into our classroom and introduce practical scenarios from the real world to our students. We are also considering

inviting some Asian traditional medication practitioners from local clinics to give lectures on acupuncture and herbal medication practice in the US. We believe that this plan will further strengthen the course offering and provide our students with insight into the most recent advances in the field.

This article's corresponding author initiated the construct of this pharmacognosy course under the supervision of the curriculum committee of the school of pharmacy. With assistance from faculty members in the school, it took the corresponding author more than a year to build the initial syllabus and contents of the course before launching the course formally in the spring of 2009.

CONCLUSION

This course delivered basic pharmacognosy knowledge and natural product chemistry to students and satisfied the related requirements from ACPE.¹⁵ The poster presentation requirement is, to our knowledge, the first (and the only) course project adapted in a pharmacognosy course in the country. As an essential component of the course, a wet laboratory practice exposed our students to herbal medication manufacture and practice in the real world, particularly with respect to qualitative and quantitative potency of natural products. Also it served the purpose of providing hands-on experience for the students to understand the importance of herbal medication regulation.

ACKNOWLEDGMENTS

This manuscript was submitted in memory of Dr. Amy Rudenko (1975-2013), who was a critical part of the course development during its infancy. The authors would like to thank all the faculty members at VCU School of Pharmacy who participated in the preparation and launching of the course, particularly, the ones who have been teaching this course, Dean Joseph DiPiro for his thoughtful suggestions on how to improve the quality of the manuscript, and Dr. Glen Kellogg who proofread the revised version of the manuscript.

REFERENCES

1. Clarke TC, Black LI, Stussman BJ, Barnes PM, Nahin RL. Trends in the use of complementary health approaches among adults: United States, 2002-2012. <http://www.cdc.gov/nchs/data/nhsr/nhsr079.pdf>. Accessed 5/2/2016.
2. Polito R. Unremarkable but exceptional. *Nutrition Bus J*. April 25, 2016.
3. Wirth EH, Voight RF. Graduate work in pharmacognosy. *Am J Pharm Educ*. 1947;11(1):78-81.
4. Voight RF. Teaching aims in pharmacognosy. *Am J Pharm Educ*. 1947;11(2):251-254.

5. Swinyard EA, Hiner LD. A plea for the complete separation of pharmacognosy from pharmacology in the instructional program. *Am J Pharm Educ.* 1947;11(4):719-724.
6. Schwarting AE, Youngken HW, Jr. Symposium on the teaching of additional subject matter in general pharmacognosy. *Am J Pharm Educ.* 1947;11(4):708-718.
7. Dutta AP, Daftary MN, Egba PA, Kang H. State of CAM education in U.S. schools of pharmacy: Results of a national survey. *J Am Pharm Assoc (Wash).* 2003;43(1):81-83.
8. Pearce KL, Cross G. A 4-week nutrition and therapeutics course in an undergraduate pharmacy program. *Am J Pharm Educ.* 2013;77(7): Article 154.
9. Bonafede M, Caron W, Zeolla M. An evidence-based elective on dietary supplements. *Am J Pharm Educ.* 2009;73(5):Article 80.
10. Islam MA. An elective course on the basic and clinical sciences aspects of vitamins and minerals. *Am J Pharm Educ.* 2013;77(1): Article 17.
11. Hussain S, Malik F, Hameed A, et al. Pakistani pharmacy students' perception about complementary and alternative medicine. *Am J Pharm Educ.* 2012;76(2):Article 21.
12. Atayee RS, Singh RF, Best BM, Freedman BA, Morello CM. An active-learning assignment involving peer-to-peer presentations to improve pharmacy students' attitudes and knowledge of dietary supplements. *Am J Pharm Educ.* 2012;76(6):Article 113.
13. Geldenhuys WJ, Cudnik ML, Krinsky DL, Darvesh AS. Evolution of a natural products and nutraceuticals course in the pharmacy curriculum. *Am J Pharm Educ.* 2015;79(6):Article 82.
14. Accreditation Council for Pharmacy Education. Accreditation standards and guidelines for the professional program in pharmacy leading to the doctor of pharmacy degree, version 2.0. <https://www.acpe-accredit.org/pdf/FinalS2007Guidelines2.0.pdf>. Accessed May 23, 2016.
15. Accreditation Council for Pharmacy Education. Accreditation standards and guidelines for the professional program in pharmacy leading to the doctor of pharmacy degree. Standards 2016. Accessed April 18, 2017.