INSTRUCTIONAL DESIGN AND ASSESSMENT

Design Considerations of a Compounded Sterile Preparations Course

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Objective. To design a comprehensive learning and assessment environment for the practical application of compounded sterile preparations using a constructivist approach.

Design. Compounded Sterile Preparations Laboratory is a required 1-credit course that builds upon the themes of training aseptic technique typically used in health system settings and threads application of concepts from other courses in the curriculum. Students used critical-thinking skills to devise appropriate strategies to compound sterile preparations.

Assessment. Aseptic technique skills were assessed with objective, structured, checklist-based rubrics. Most students successfully completed practical assessments using appropriate technique (mean assessment grade=83.2%). Almost all students passed the practical media fill (98%) and gloved fingertip sampling (86%) tests on the first attempt; all passed on the second attempt.

Conclusion. Employing a constructivist scaffold approach to teaching proper hygiene and aseptic technique prepared students to pass media fill and gloved fingertip tests and to perform well on practical compounding assessments.

Keywords: compounded sterile preparations, laboratory, assessment

INTRODUCTION

It is critical to educate all pharmacists and regulators about appropriate compounding of sterile preparations (CSP) to prevent incidents in which contaminated sterile preparations cause the deaths of otherwise healthy recipients.¹⁻³ The Accreditation Council for Pharmacy Education (ACPE), the American Association of Colleges of Pharmacy, and the National Association of Boards of Pharmacy have all promulgated competency statements related to CSP for pharmacy education, though none of these statements address the methodology for CSP instruction in the classroom or the cleanroom.⁴⁻⁶

In modern health care systems, compounding pharmacies meet special patient care needs.^{2,7} However, while the role of compounding pharmacies continues to expand, the fundamental teaching of compounding has decreased.⁸ Reports show the utility of simulation in compounding education, but pharmacists require hands-on training to be competent in aseptic technique.⁹

Previous surveys of schools and colleges of pharmacy report the frequency and depth of compounded sterile preparation education.¹⁰⁻¹³ Hellmus et al found that all respondent schools included some type of instruction on

CSPs. Despite this promising response, only 70% (n=37) required students to compound on their own (rather than in groups or not at all), and only 21% (n=11) offered a standalone course on this topic. The majority of responding schools (88%) taught students about United States Pharmacopeia (USP) standards for sterile compounding (Chapter 797).¹² It should be noted, however, that their study was conducted soon after USP 797 was published. Most schools at that point would only have been in the process of addressing the chapter. The current state of how USP 797 is covered in curricula is unknown.

The 2007 ACPE Accreditation Standards detailed the learning objectives for instruction regarding sterile admixture techniques, USP 797, stability and sterility testing, clean room requirements, and infusion devices and catheters. The 2016 Standards, however, only provide learning outcomes.^{4,14}

Extracting the detailed components of sterile preparations from the previous ACPE Standards 2007 and using them in combination with current ACPE Standards 2016 is necessary to develop an effective curriculum for pharmacy students. Furthermore, USP Chapter 800, which at the time of writing was under review, promulgates hazardous drug handling changes that will impact not only health-system pharmacy but community practitioners as well.¹⁵ Schools of pharmacy should anticipate the need to incorporate the latest handling procedures into their curriculum.

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While components of compounded sterile preparations education are reported in the literature, including grading rubrics, improvements in media fill test pass rates, the impact of prior experience on learning outcomes, and the importance of repeated testing to improve skills, no study has fully described the design considerations of such a course.¹⁶⁻¹⁹ A successfully designed course would be of value to the academic community as only 13% of schools of pharmacy (n=7) reported that they felt confident their students had adequate training in compounding sterile preparations prior to graduation.¹² Additionally, few hospitals allow students to practice compounding in practice experiences.¹⁹

Changing demands of the field may require schools of pharmacy to provide students with better opportunities to learn and practice aseptic techniques. Specialty pharmacy is a growing industry focused on high cost injectable and infused formulations.²⁰ The scope of pharmacy practice continues to evolve throughout the country. Moreover, the paradigm shift of CSP oversight from the traditional health-system pharmacist to nontraditional expanded roles in specialty pharmacy necessitates the education of future pharmacists in CSP. To that end, this paper addresses design considerations of a comprehensive learning and assessment environment for the practical application of compounded sterile preparations.

DESIGN

Compounded Sterile Preparations Laboratory is a required 1-credit course with three contact hours per week; one hour of prelaboratory lecture and instruction followed by two hours of hands-on application. The instructors sought to make the laboratory practical, efficient, and cost-effective. The most pertinent design considerations were logistics, cost, student assessments, and time with “needle in hand.”

The prelaboratory sessions presented new material and demonstrations of the CSP for the week. They were developed using a constructivist approach, which allowed students to create new knowledge by building on the previous sessions’ concepts. Instructors provided the framework for success and expected students to apply that basic knowledge in the laboratory. While the constructivist approach was appropriate for teaching course concepts, a structured approach was more appropriate for the technical aspects of compounding sterile preparations. However, the constructivist philosophy still applied in the sense that students may have required modification of hand washing and aseptic technique based on hand size and manual dexterity. Therefore, students had to figure out what worked for them while maintaining the integrity of the process.

For the structured approach to this course, checklists similar to Objective Structured Assessment of Technical Skills used in surgical education and were designed and used for each of the assignments.²¹ Surgical checklists reduce morbidity and mortality by ensuring that important steps are not missed in the surgical procedure.²² The authors posited that this theory was transferrable to compounded sterile preparation education and that checklists would allow students to accurately perform required tasks. The checklist included each required step for the activity (Table 1). These activities can be transferrable to other schools looking to employ a checklist for teaching compounding sterile preparations. The checklist provides more specific feedback to students performing the assessment compared to published

Table 1. USP 797 Garbing/Hygiene Assessment²⁸

Upon Arrival:
Arrives properly groomed
Has no rashes, weeping sores, sunburn, conjunctivitis, or respiratory infection
Long hair is pulled back or up in a bun
Beard/facial hair is neat and trimmed
No visible piercings
Wears no makeup
Wears no nail polish or artificial nails
Natural nails neat and trim
Wears clean, nonshedding clothing
Wears closed-toe shoes
Not chewing gum, eating, or drinking
Removes all jewelry and watches
The following must be done in order:
Dons shoe covers properly – lifting off the sticky mat and placing on the floor – shoe covers should not touch sticky mat at any time until learner exits
Dons hair cover/bouffant; hair does not stick out of the bouffant
Dons beard cover if applicable
Dons mask – blue side out
Properly contours mask to face
Ties mask appropriately – mouth not visible from side, no gaps or pockets
Washes hands; see separate handwashing checklist
Dons gown
Washes hands with Avagard
Gloving
Touches only the fold
Does not cross over sterile area or let gown touch sterile area
Pinches cuff with one hand
Tips glove point downward
Scoops remaining glove with gloved hand
Tips of glove point downward
Scoops glove over cuff of gown
Rinses gloves with sterile 70% isopropyl alcohol

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rubrics.¹³ Instructors can adapt this and assign percentages to checklist items as they see fit.

Compounded sterile preparation education in the workplace is typically conducted one-on-one. Incorporating the positive aspects of one-on-one education with the logistics of student enrollment numbers, laboratory space, and cost present the greatest challenges when designing this type of course. Seventy-five students were enrolled in the laboratory and were divided into three sections of 25 students. Based on hood space and logistics of observing students, each section of 25 was again divided into three groupings, forming a total of 9 groups with 8-10 students per group. Final groups were encouraged to select a team name and work as a cohesive unit. Based on these subdivisions, a minimum of three faculty members were required to run each session. The three groups in each 2-hour session rotated among the three faculty members, each of whom facilitated a 40-minute activity (see Table 2 for course outline). Each week, students spent one 40-minute session in the IV room, which required a full gown and garb and was supervised by the primary instructor. The other two sessions focused on technique necessary for the IV room session and/or topics applicable to CSPs.

Four overarching themes predicated the course design: (1) providing experiences similar to training in a health-system setting; (2) simulating USP 797 standard operating procedures; (3) threading other curricular competencies such as pharmaceuticals and pharmacy calculations; and (4) scaffolding course material (see Table 3 for specific course objectives). The sequence of the course was similar to that of aseptic technique taught in a health-system setting.^{25,26} Before any compounding took place, students had to demonstrate the ability to appropriately wash hands, gown, garb, and clean and disinfect primary engineering controls (eg, laminar airflow hoods). The laboratory adopted the WHO 7-step hand washing technique.²⁷ Online resources to help reinforce the WHO 7-step method were made available to students as supplementary material.

The contents of USP 797 can be distilled into three distinct parts: environment, personnel, and equipment. While aseptic technique and the preparation of CSPs are important and have been the traditional focus, preparation for practice requires an understanding of these components. For example, weekly quality assurance checks, such as temperature and simulated pressure differential monitoring in the clean room area familiarized students with some of the regulatory compliance issues. Values outside of normal

Table 2. Outline for the Compounded Sterile Preparations Course

Week	Lecture Topic	IV Room	Session 1	Session 2
1	Orientation			
2	Personal Hygiene	Garbing	Hand Washing	Surgical Scrub
3	Hood Anatomy and Cleaning	Hood Cleaning	Hand Washing/Surgical Scrub	Garbing
4	Expiration Dating and Labeling Requirements	Hand Washing, Surgical Scrub, Gloved Fingertip Assessment, and Hood cleaning		
5	Admixture, Working in a Hood, Syringes and Needles	Basic Syringe technique	IV Catheters	Stability ("Trissels" and King) ^{23,24}
6	USP 797	LVP/SVP	USP 797	Video Technique Review
7	Stability and Compatibility	LVP/SVP	Administering IV	NIOSH/OSHA
8	Mid-term Examination		Sterility Testing and Media Fill Assessment	
9	Pediatrics and Preservatives	Pedi Dilutions	IV Errors	Patient Controlled Analgesia
10	Ophthalmic Preparations	Ophthalmic Preparation	Isotonicity	Video Technique Review
11	Parenteral Nutrition	TPN	Osmolarity	Rate Calculations
12	Home Infusion		Product Preparation Assessment	
13	Work Practices Regarding Hazardous Drugs	Chemo Practice	Chemo Regimen Prep	HazMat Introduction
14	Hazardous Drug Disposal and First Aid	Chemo Regimen Prep	HazMat Spill	Video Technique Review
15	Chemotherapy		Chemotherapy Assessment	

IV=intravenous; LVP=large volume parenteral; SVP=small volume parenteral; NIOSH=National Institute of Occupational Safety and Health; OSHA=Occupational Safety and Health Administration; TPN=total parenteral nutrition; Pedi=pediatrics; USP=United States Pharmacopeia; HazMat=hazardous materials

Table 3. Learning Objectives for the Compounded Sterile Preparations Course

After taking this course, the learner should be able to:
1. Demonstrate the proper procedures and techniques required for aseptically compounding sterile preparations.
2. Prepare proper documentation and labeling of products.
3. Identify potential sources of medication errors.
4. Analyze methods to prevent contamination of sterile product preparations.
5. Describe principles of quality assurance in sterile compounding within United States Pharmacopeia Chapter 797.
6. Compare the relationship of dosage form to stability, storage, compatibility, and handling procedures.

ranges were intentionally set at random intervals not just to see if students identified the variation, but also to allow them to think critically and create an action plan for how to rectify the deviations.

Implementation of a prescribed dress code was the first step towards adherence to USP 797 personnel standard operating procedures. The laboratory syllabus included strict language requiring adherence to USP 797 guidelines for attire.²⁸ Similar to an actual compounding setting, any learner arriving not in adherence to the attire policy would not be allowed into the laboratory.

The laboratory provided the opportunity to thread the application of concepts learned in other courses such as pharmacy calculations and drug information. For example, students calculated nutritional requirements and subsequently compounded a total parenteral nutrition bag. Students investigated the compatibility of compounds and used critical-thinking skills in interpreting that information.

Hand washing and garbing served as the foundation for scaffolding aseptic technique and theory throughout the semester. For each assessment, expectations were built on this foundation and increased as the semester progressed (see nested hand washing assessment in the second column of Table 1). For example, for one to succeed in the sterility testing assessment, the student first needed to demonstrate the ability to wash hands and gown, don gloves, and clean the primary engineering control before they would be able to start the sterility testing assessment.

EVALUATION AND ASSESSMENT

The laboratory evaluation was comprised of four practical assessments, one midterm examination, one final examination, weekly quizzes, and participation points. The assessments were designed so the class would have at least two guided practice sessions before being assessed on a competency.

In addition to instructor feedback on technique, some of the 40-minute laboratory sessions were devoted to

students filming their technique with the college's laptop video program and personal smart phones. The students could then compare their technique and process with the rubrics. The rubrics were similar to the ones published by Brown in 2006;¹³ however, they were augmented with step-by-step checklists for appropriate aseptic technique.

Per USP 797 requirements, a media fill sterility test and a gloved fingertip test constituted the second assessment. In practice, passing three of each is required to prepare CSPs; however, for time and financial reasons, students completed one of each. We used tryptic soy broth media for the sterility test and tryptic soy agar for the gloved fingertip test. A remediation was provided for students whose preparations yielded any microbial growth. Media fill test pass rates at the midpoint of this course were similar to those in previous studies that measured contamination rates at the end of course (Table 5).¹⁶ In theory, this indicated an earlier proficiency and allowed for students to spend more time perfecting their aseptic technique. All unsuccessful students passed the media fill and gloved fingertip test on remediation (Table 5: media fill remediation cohort 1: n=2; cohort 2: n=1/gloved fingertip remediation cohort 1: n=8; cohort 2: n=13).

Subsequent practical assessments included a practical preparation of a large (cohort 1) or small (cohort 2) volume parenteral product as well as a chemotherapeutic regimen (see Table 2 for description of assessments). The use of standardized rubrics and checklists allowed faculty members to identify thematic issues with knowledge or technique and address as needed. For example, instructors were able to identify that 10 students in cohort 2 were inappropriately spraying sterile isopropyl alcohol toward the HEPA filter during the first assessment. Instructors were able to redirect students prior to the next session, resulting in correct alcohol spraying in the subsequent assessment. Grades for each of the practical assessments are presented in Table 4. Most students performed well, and the average assessment grade was usually a B (80%) or better.

DISCUSSION

This course design provides a framework for other schools of pharmacy looking to rework or add a CSP laboratory. Material cost is a factor for institutions designing similar laboratories. Although tryptic soy broth and agar are major costs, performing at least one media fill and gloved fingertip test provides students with a realistic experience. Instructors may want to budget for extra tryptic soy products for remediation, as well as calcium and phosphate containing products to demonstrate what a precipitate looks like.

There are a number of pearls that pharmacy schools can take away from our experience creating this course. During the initial offering, instructors provided fresh

Table 4. Practical Assessments for the Compounded Sterile Preparations Course

	Average Grade, % (SD)	
	Cohort 1	Cohort 2
Handwashing, Garbing, and Hood Cleaning	84.6 (9.1)	83.7 (8.6)
Sterility Testing	83.3 (5.9)	85.4 (7.4)
Compounded Sterile Preparation	83.2 (9.6)	81.3 (8.0)
Hazardous Material Preparation	81.6 (10.0)	82.5 (7.5)

gowning materials for every laboratory session. Based on student feedback and budget constraints, during the subsequent offering, students were issued five complete gown/garb sets for repeated use. While the second offering was more economical and environmentally friendly, students did not take the garbing process as seriously when donning a used gown instead of a fresh one. The second takeaway is to examine the time students spend under the hood or with needle and syringe in hand. The course outline (Table 2) called for students to prepare at least one CSP each session. There is an aspect of muscle memory when learning this material, and without repetition, this can be easily forgotten.

Previous research found that prior work experience was a predictor of student success in this type of laboratory setting.¹⁶ Therefore, instructors may consider using students with hospital experience to help moderate the laboratory. However, these students were not able to unlearn bad technique and habits in the duration of the course; whereas, students initially learning techniques within the laboratory setting performed better on practical assessments.

The constructivist approach was difficult for many students; it was a challenging for them to learn material that involved complex problem solving instead of one correct answer. In an ideal setting, there would be one correct method for everyone. However, technique is predicated on variations in hand size and manual dexterity, so everyone performs manipulations slightly differently. The tenets of aseptic technique do not change, but the execution is different.

Paper-based checklists were used to provide feedback to students. Instructors who have access to tablet computers and a learning management system that would support a checklist for grading are encouraged to build content electronically for ease of grading and data mining. When reviewing rubric data, instructors should pay attention to the basic tenets of aseptic technique, such as not blocking first air, crossing over critical sites, and maintaining an appropriate depth while working in the laminar flow hood. If a trend of mistakes is identified, these errors should be addressed immediately. A review of the rubrics

Table 5. Sterility Testing Pass Rates in the Compounded Sterile Preparations Course

	Gloved Fingertip Test Pass Rate, % (# failed)	Media Fill Pass Rate, % (# failed)
Cohort 1 (N=75)	89.3 (n=8)	97.3 (n=2)
Cohort 2 (N=76)	86.8 (n=13)	98.7 (n=1)

used in the two cohorts yielded areas that appeared to be a challenge for students, such as “places protective cover of needle on alcohol pad,” but did not significantly impact aseptic technique. Students in both cohorts found the transition to negative pressure technique to prepare chemotherapeutic regimens in week 13 challenging (Table 2). Faculty members should anticipate this difficulty after using standard aseptic technique for most of the semester and stress the importance of negative pressure technique when working with hazardous materials.

The course was designed so weekly assignments and participation points would be easily attainable. However, from the student perspective, this proved to be difficult. The course was offered during the same semester that students started their therapeutic classes. The juxtaposition of a CSP laboratory with therapeutics did not bode well for perceptions of the course. Students thought it was too much work for a 1-credit class, and many questioned its utility in the curriculum. The dress code was wildly unpopular. However, the instructors felt strongly that in a professional setting, students should be able to adhere to simple standards relevant to compounded sterile preparations.

Future directions of the course include incorporating an electronic medical record (EMR) for hi-fidelity simulation of order processing. In the absence of an EMR, students could be assigned a preparation when entering the cleanroom to better simulate receiving an order in a hospital. Additionally, the authors plan to incorporate hood-mounted cameras to assist with grading and feedback.

SUMMARY

Employing a constructivist scaffold approach to teaching proper hygiene and aseptic technique prepared students to pass media fill and gloved fingertip tests and to perform well on practical compounding assessments. While the creation of a standalone CSP course is a challenging undertaking for any school of pharmacy, the effort better prepares students for future practice. Students completed the CSP laboratory with an understanding of the details of USP 797 so they could monitor environment, personnel, and equipment in an IV room. Such a course ensures student success in a compounding setting and prepares new pharmacists to minimize contamination risks.

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REFERENCES

1. Myers CE. History of sterile compounding in US hospitals: learning from the tragic lessons of the past. *Am J Health Syst Pharm*. 2013;70(16):1414-1427.
2. Moehring RW, Lewis SS, Isaacs PJ, et al. Outbreak of bacteremia due to burkholderia contaminans linked to intravenous fentanyl from an institutional compounding pharmacy. *JAMA Intern Med*. 2014;174(4):606-612.
3. Shaughnessy AF. Meningitis outbreak shines light on compounding pharmacies. *BMJ*. 2012;345:e7432.
4. Accreditation Council for Pharmacy Education. Accreditation standards and guidelines for the professionals program in pharmacy leading to the doctor of pharmacy, version 2.0. Feb 14, 2011. <http://www.acpe-accredit.org/pdf/FinalS2007Guidelines2.0.pdf>. Accessed Aug 6, 2015.
5. Medina MS, Plaza CM, Stowe CD, Robinson ET, DeLander G, Beck DE, et al. Center for the Advancement of Pharmacy Education 2013 Educational Outcomes. *Am J Pharm Educ*. 2013;77(8):Article 162.
6. Pharmacy compounding of sterile products. Jun 5, 2013. <https://www.nabp.net/news/pharmacy-compounding-of-sterile-products-resolution-109-1-13>. Accessed Aug. 6, 2015.
7. Guharoy R, Noviasky J, Haydar Z, Fakih MG, Hartman C. Compounding pharmacy conundrum: "we cannot live without them but we cannot live with them" according to the present paradigm. *Chest*. 2013;143(4):896-900.
8. Newton DW. Compounding paradox: taught less and practiced more. *Am J Pharm Educ*. 2003;67(1):Article 5.
9. Patel S, Vincent AH, Abel SR, Jacobs CM, Dunlop SR, Seibert M. A virtual clean room to teach USP 797 regulations for intravenous medications. *Am J Pharm Educ*. 2011;75(1):7.
10. Miller CM, Cordova MA, Hladik WB. The status of undergraduate instruction in parenteral products at U.S. colleges of pharmacy. *Am J Pharm Educ*. 1983;47:48-51.
11. Monk MR, Brown TR, Garner DD, Smith MC. The status of home intravenous therapy instruction provided by U.S. schools and colleges of pharmacy. *Am J Pharm Educ*. 1991;55(2):120-124.
12. Hellums M, Alverson SP, Monk-Tutor MR. Instruction on compounded sterile preparations at U.S. schools of pharmacy. *Am J Health Syst Pharm*. 2007;64(21):2267-2274.
13. Brown MC, Conway J, Sorensen TD. Development and implementation of a scoring rubric for aseptic technique. *Am J Pharm Educ*. 2006;70(6):Article 133.
14. Accreditation Council for Pharmacy Education. Accreditation standards and guidelines for the professionals program in pharmacy leading to the doctor of pharmacy, Standards 2016. Available from: <https://www.acpe-accredit.org/pdf/Standards2016FINAL.pdf> Accessed Aug 6, 2015.
15. United States Pharmacopeia General Chapter <800> Hazardous drugs – handling in healthcare settings. Draft PF40(3). http://www.usp.org/sites/default/files/usp_pdf/EN/m7808_pre-post.pdf. Accessed Aug 6, 2015.
16. Isanhart CM, McCall KL, Kretschmer D, Grimes BA. Parenterals laboratory course to reduce microbial contamination rates in media fill tests performed by pharmacy students. *Am J Pharm Educ*. 2008;72(2):Article 27.
17. Ratka A, Demps E, Mack A. The effect of prior experience with aseptic techniques on learning outcomes in a sterile compounding laboratory course. *Currents in Pharmacy Teaching and Learning*. 2012;4(1):19-28.
18. Begley K, Monaghan MS, Qi Y. Repeated testing to improve skills in a pharmacy practice laboratory course. *Am J Pharm Educ*. 2013;77(6):Article 130.
19. Wuller WR, Kwasiborski CL. Developing entry-level competencies in sterile product preparation: an emerging challenge for pharmacy schools and experiential practice sites. *Am J Health Syst Pharm*. 2012;69(12):1072-1075.
20. Hagerman J, Freed S, Rice G. Specialty pharmacy: a unique and growing industry. American Pharmacists Association. <http://www.pharmacist.com/specialty-pharmacy-unique-and-growing-industry>. Accessed August 6, 2015.
21. Martin JA, Regehr G, Reznick R, Macrae H, Murnaghan J, Hutchison C, et al. Objective structured assessment of technical skill (OSATS) for surgical residents. *Br J Surg*. 1997 Feb 1;84(2):273-8.
22. Haynes AB, Weiser TG, Berry WR, Lipsitz SR, Breizat A-HS, Dellinger EP, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med*. 2009;360(5):491-499.
23. Handbook on injectable drugs. 18th ed. Bethesda, MD: American Society of Health-System Pharmacists; 2014.
24. King JC. Guide to parenteral admixtures. Napa, CA: King Guide Publications, Inc; 2016.
25. American Society of Health-System Pharmacists. ASHP guidelines on compounding sterile preparations. *Am J Health Syst Pharm*. 2014;71(2):145-166.
26. Kastango ES, Bradshaw BD. USP chapter 797: establishing a practice standard for compounding sterile preparations in pharmacy. *Am J Health Syst Pharm*. 2004;61(18):1928-1938.
27. WHO | WHO guidelines on hand hygiene in health care. <http://www.who.int/gpsc/5may/tools/9789241597906/en/>. Accessed January 28, 2015.
28. United States Pharmacopeia General Chapter <797> http://www.usp.org/sites/default/files/usp_pdf/EN/USPNF/usp-gc-797-proposed-revisions-sep-2015.pdf