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INSTRUCTIONAL DESIGN AND ASSESSMENT

A Shared Assignment to Integrate Pharmaceutics and Pharmacy Practice Course Concepts

Autumn L. Stewart, PharmD, Ira S. Buckner, PhD, and Peter L.D. Wildfong, PhD

Mylan School of Pharmacy, Duquesne University

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Objective. To demonstrate for first-year pharmacy students the relevance of pharmaceutics course content to pharmacy practice by implementing a joint, integrated assignment in both courses and assessing its impact.

Design. Medication errors and patient safety issues relevant to ophthalmic and otic formulations were selected as the assignment topic. A homework assignment based on a mock court case involving a patient who was given an inappropriate formulation because of a pharmacist's medication error was given to students. The scenario was followed by essay and calculation questions linking physical pharmacy concepts with patient safety recommendations.

Assessment. Students' average score on the crossover assignment was 88.7%. Minute papers completed before and after the assignment showed improvement in student learning. Students' scores on examination questions related to the assignment topic were significantly higher than the previous year's students' performance on similar questions. In a survey conducted at the end of the semester, 91% of students indicated that the assignment helped them relate the covered topics to future practice, and 98% agreed that the assignment emphasized the importance of the pharmaceutics in professional practice.

Conclusion. A crossover assignment was an effective means of demonstrating the connection between specific pharmaceutics concepts and practice applications to pharmacy students.

Keywords: pharmaceutics, pharmacy practice, curriculum integration, ophthalmic medications, otic medication, course integration

INTRODUCTION

The Accreditation Council for Pharmacy Education (ACPE) requires colleges and schools of pharmacy to adequately address, among other areas, pharmaceutics, pharmacy practice, and medication safety in the doctor of pharmacy (PharmD) curriculum. Pharmacy graduates must have the knowledge base and competence level to deliver effective patient care. The standards also promote the enhancement of students' critical-thinking skills.[1] Historically, pharmacy education has employed a ''teacher-centered'' approach with limited integration between disciplines, which often results in students learning in ''silos.''[2] This teaching model assumes that students will make the connections between interdisciplinary concepts themselves as they complete the required curriculum and do not need faculty members to explain them. However, they often struggle to apply basic science concepts, like those learned in pharmaceutics, to patient care.

Corresponding Author: Autumn Stewart, 204 Muldoon Building, 600 Forbes Avenue, Pittsburgh, PA 15282; Phone: 412-396-1321, Fax: 412-396-2161, Email: runyona@duq.edu

The profession, and in turn, pharmacy education, continues to evolve from a product-centered focus to one that is increasingly patient centered. This shift to an emphasis on clinical care leaves many students struggling to understand and appreciate the relevance of basic science coursework.

The value of basic science instruction as a foundation of pharmacy education is essential in contemporary pharmacy practice, and evidence-based decision making is frequently not appreciated by pharmacy students. To bridge this gap in understanding, faculty members have implemented pedagogical links between the foundational sciences and patient care.[3-5] In one curriculum-wide approach requiring extensive faculty cooperation and time, first-year pharmacy students selected a volunteer patient who became the subject of 15 assignments spanning 8 courses. The year-long initiative resulted in increased student understanding of the relationship between the pharmaceutical sciences and pharmacy practice [3]

In this study, we describe the development and implementation of a novel ''crossover'' assignment to bridge introductory courses in pharmaceutics and pharmacy

practice as an example of horizontal curricular integration in the first year of a PharmD program. We also evaluate the impact of this assignment on student learning outcomes and beliefs pertaining to the relevance of pharmaceutics in pharmacy practice.

DESIGN

This study used both qualitative and quantitative methods. Review by the institution's internal review board deemed the project exempt. Participants were first-professional degree PharmD students enrolled concurrently in 2 required courses: Pharmaceutical Principles and Drug Delivery Systems I, and Pharmacy Practice I: Introduction to Pharmaceutical Care. Within the pharmacy practice course, students gained experience in the use of drug information resources and the important role that pharmacists play in identifying and managing drug-related problems, adverse drug reactions, drug interactions, and medication errors. The pharmaceutical principles course covered traditional pharmaceutics areas, including basic physical pharmacy, formulation of a variety of dosage forms, and introductions to drug delivery from numerous types of drug products.

The course instructors, a clinical pharmacy faculty member and 2 pharmaceutical scientists, held preliminary planning sessions prior to the start of the semester to compare lecture sequences and identify potential crossover nodes within the 2 courses around which the assignment could be built. In-depth topic analysis revealed multiple points within the 2 courses where an integrated assessment could be conducted. Ultimately, the instructors selected medication errors/patient safety issues relevant to ophthalmic/otic formulations, including tonicity calculations, based on the position of these topics at the approximate midpoint of the semester. Formulation concepts and tonicity calculations can be key in medication errors involving otic and ophthalmic products. In previous years, students struggled to master tonicity calculations and did not appreciate the relevance of this topic within contemporary pharmacy practice. Also, the timing of these 2 topics in the curriculum allowed the assignment to be completed in 1 month.

The instructors wrote a scenario that involved a mock court case in which a medication error directly contributed to patient injury, the source of which was a pharmacist's lack of understanding of appropriate formulation and its effects on tonicity (Appendix 1). Specifically, the inadvertent medication error was the result of the pharmacist's lack of knowledge about the importance of tonicity in ophthalmic formulations and of the critical differences in formulation components between otic and ophthalmic products (both were concepts emphasized in the pharmaceutics course). The instructors also included several practice-related issues in the assignment, including poor penmanship (on the mock prescription), errors resulting from "look alike, sound alike" drugs, and ambiguous or easily misread prescription abbreviations.

Prior to the semester, the course faculty members adjusted their lecture schedules to allow for assignment launch and post-assignment debriefing. This provided the forum in which the pre- and post-assignment minute papers and follow-up survey data were collected, as well as meaningful dissemination of clear expectations and discussion on class responses. Having all faculty members present at both the assignment launch and the debriefing lecture was important to ensure that the details of the project were described explicitly. The launch of the assignment occurred in the Pharmaceutics class simultaneous to the coverage of medication safety and tonicity in each respective course.

The students were given a homework assignment, via Blackboard (Blackboard Inc, Washington DC) with the written court case at the top, followed by a series of short-answer essay and calculation questions that highlighted the necessity of understanding fundamental pharmaceutical principles to ensure patient safety. The questions required students to communicate their interpretations in writing using precise descriptive language. Students were given 4 weeks to submit their responses via Blackboard. The required assignment counted as a portion of the overall grade in both courses.

After completed assignments were submitted, the debriefing session was held during Pharmaceutical Principles where each assignment question was shown on the lecture hall screen and students were asked to volunteer their answer to the rest of the class. The instructors reviewed each question with the class in order to convey correct answers as well as to provide rationale for grades received. Each answer was discussed, and the class was pressed to add details to the discussion (from their own answers) that they felt were missing.

EVALUATION AND ASSESSMENT

Student learning and opinions about the assignment were assessed by the crossover assignment minute papers, specific questions on the final examination in pharmaceutics, and a student survey administered at the end of the semester (Table 1). The entire class (189 students) completed the crossover assignment (graded portion). Of the 189 students, 82.5% completed the non-graded assesments (minute papers and follow-up survey).

Crossover Assignment

Students' final scores on the crossover assignment were calculated and reported using descriptive statistics.

Table 1. Results of a Crossover Assignment Intended to Integrate Pharmaceutics and Pharmacy Practice Course Concepts

Outcome Measure	Instrument	Results
Student learning	Crossover assignment	The average score was 88.7%, with 23 and 27 students having received deficient scores on the pharmaceutics and pharmacy practice sections, respectively.
Student learning; transferability of knowledge to concept areas.	Minute Papers	Significant change ($p < 0.001$) in the quality and depth of students' explanations of the relevance of pharmaceutics to pharmacy practice between the pre- and post-assignment exercises.
Student learning	Final examination scores	Mean score from questions pertaining to tonicity and ophthalmic/otic solution formulation (94% ± 15%) were significantly improved ($p < 0.001$) compared with the previous year examination scores on the same topics (69% ± 25%).
Student beliefs; transferability of knowledge to concept areas	Student survey	The majority of students indicated a positive impact on their appreciation for the applicability of this topic and others to pharmacy practice.

The average score on the case scenario portion of the project was 88.7%. Of the 189 assignments submitted, only 23 received deficient scores (< 70%) on the tonicity and ophthalmic/otic solution formulation questions. A similar number of students (27) received deficient scores on the medication errors section. Many of the students who received a deficient score on one section also received a deficient score on the other section, although a few exceptions to this did occur.

Minute Papers

Students were asked to complete 2 minute-paper exercises in class to measure the impact of the assignment on student learning and students' ability to transfer knowledge pertaining to the relevance of a topic to other concept areas within the course. The first minute-paper was completed immediately prior to presenting the crossover assignment. Students were provided with a list of basic pharmaceutics topics covered in the preceding 6 weeks and asked to write a minute paper explaining how a topic of their choice was relevant to pharmacy practice. Students were not given feedback on their responses. The second minute-paper was completed immediately following the submission of all crossover assignments. Students were asked to choose a different topic from the original list of concepts and write another minute paper explaining how their second topic would be relevant to practice as a pharmacist.

Responses from the minute papers were reviewed independently by the 3 participating instructors and ranked into 1 of 3 categories: (1) the student understands the topic's relevance and provides a developed explanation; (2) the student somewhat understands the topic's relevance and provides a semi-developed explanation; (3) the student does not understand the topic's relevance and provides an undeveloped explanation. A final ranking was applied to each minute paper by calculating the average score from all instructors.

All scores were entered into Microsoft Excel and comparisons between the pre-assignment and post-assignment papers were made using a paired student's *t* test. Analysis of the minute papers demonstrated a significant change ($p < 0.001$) in the quality and depth of students' explanations of the relevance of pharmaceutics to pharmacy practice between the pre-assignment and post-assignment.

Final Examination

To measure the impact of the crossover assignment on student learning, students' scores on questions pertaining to tonicity and formulation of otic and ophthalmic products were compared with the previous year's class scores on similar questions. Questions from each examination are provided in Appendix 2. Mean scores were compared using an unpaired student's *t* test. The comparisons showed a significant improvement in scores (69% ± 25% in 2008 vs. 94% ± 15% in 2009; $p < 0.001$).

Student Survey

Following completion of the post-assignment minute paper, the instructors administered a brief, in-class follow-up survey to measure students' opinions regarding the relevance of pharmaceutics to pharmacy practice and potential transference of these perceptions to other topics within the course. Students were asked to rank their level of agreement with the following 3 statements using

a 4-point scale: (1) The example covered in the crossover assignment helped me to make a connection with another topic that I may see in the future; (2) The crossover assignment helped me to appreciate the importance of tonicity in pharmacy practice; and (3) As a result of the crossover assignment, pharmaceutics seems more relevant to my career as a pharmacist. Student responses were collected anonymously using a classroom personal response system.

Ninety-eight percent of students thought the assignment helped them better appreciate and apply tonicity in pharmacy practice; 91% believed the assignment would help them to similarly relate other pharmaceutics topics to practice in the future; and 86% agreed that the assignment exemplified the relevance of pharmaceutics in professional practice (Table 2).

DISCUSSION

Development of the crossover assignment (case, integrated questions, and additional assessment strategies) required continuous communication between instructors from both courses. In addition to the ophthalmic/otic formulations, the instructors identified several other topics with potential to be the subject of future crossover assignments, made possible through strategic re-sequencing of topics. This would allow for year-to-year variability in the topics of focus in the assignment itself.

Initial effort also was expended on establishing the logistics of offering a common assignment between 2 classes. One challenge immediately identified by the instructors was that the class rosters were not identical for the 2 courses. Approximately 20 students were repeating pharmaceutics, while no students were repeating the pharmacy practice course. The instructors decided that all students would be responsible for answering all questions, despite the small group of students who were taking only 1 of the 2 classes. This decision was met with some resistance from the repeat students, who argued that they should not be graded on pharmacy practice topics because they had successfully completed that course in the previous year. The instructors provided a unified argument that requiring repeat students to demonstrate competency in content from previous classes was justified as their abilities to integrate different types of information and translate it to practice would be assessed. The instructors also decided that the grade received on the crossover assignment should be applied in both courses (except in instances where repeat students were only enrolled in 1 course). The faculty members believed that this was critical not only for the sake of integrated thinking and problem solving, but also to prevent students from arbitrarily focusing on content specific to only 1 of the 2 courses. This required a uniform commitment from faculty members and students in both courses, and both course syllabi were adjusted to reflect this combined assessment prior to the semester.

An additional time commitment between course faculty members was required to teach and coach one another on perspectives and technical information outside of their specific disciplines. This was deemed essential to establish a consistent plan for handling student questions (which proved to integrate topics between both courses), and provide uniform advisement during the month in which students were working on the assignment. This was facilitated by meetings between the instructors prior to assignment launch to provide cross-disciplinary coordination, and involved shared access between course Blackboard sites. We believe that the amount and nature of interaction between course instructors resulted in more effective integration of distinct course concepts than would have been accomplished without extensive faculty collaboration. Previous attempts to bridge concepts were typically unilateral, and attempted within a course only by the faculty member(s) responsible for that course. While such unilateral attempts probably are beneficial and improve students' comprehension and basic application of

Table 2. Pharmacy Students Opinions Regarding a Crossover Assignment Intended to Integrate Pharmaceutics and Pharmacy Practice Course Concepts

Question	Strongly Disagree (%)	Disagree (%)	Agree (%)	Strongly Agree (%)	Mean Response[a]
The example covered in the crossover assignment helped me to make a connection with another topic that I may see in the future.	5	4	61	30	3.2
The crossover assignment helped me to appreciate the importance of tonicity in pharmacy practice.	1	1	63	35	3.3
As a result of the crossover assignment, pharmaceutics seems more relevant to my career as a pharmacist.	5	9	63	23	3.0

[a] Scores were based on a Likert scale on which 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

specific concepts, they only reflect the perspectives and expertise of one group of faculty members, eg, only clinical faculty members or only basic science faculty members. As a result of our collaboration, we were able to extend the bridge between concepts further and encourage deeper levels of learning than if we had worked independently.

Students appeared to enjoy the discussion format used for the debriefing after their assignments were submitted, and there was considerable enthusiasm to participate in reaching a consensus on the correct answers despite the size of the class. When asked to volunteer answers to a question, more students were eager to participate than was typical in a general discussion held during a course lecture session. The instructors believed that this eagerness reflected students' satisfaction with the assignment and confidence in their responses, which may have stemmed from the month they were given to formulate their answers. Confidence derived from lengthy consideration and reflection might simulate a level of "experience" with the content that is not typically seen in first-year students. The confidence that students developed through the exercise might translate into an eagerness to counsel one another on answers in a large lecture setting and ability to participate in such discussions with a patient.

Enthusiasm for this integrated approach to learning was reflected in students' responses to the course survey. Students praised the crossover assignment for its overall organization and implementation and felt that the expectations were well communicated. At the course level, the instructors noted improvements in students' evaluation of instructional design and delivery of assignments compared with previous years. The crossover assignment subsequently was recognized by the school's administration as an excellent example of horizontal integration within the PharmD curriculum. This concept of horizontal integration will be applied in future offerings of these and other courses in the curriculum.

Not only did most students develop an appreciation for the connection between the content of the 2 courses; their ability to describe these connections also improved. Pharmacy students generally have less difficulty relating medication errors to practice than they do excipient functionality. In previous years, this area was noted as one of the most difficult areas for students to demonstrate competence. A comparison of the results from the final examination questions on these topics demonstrated improved ability to recall, comprehend, and apply content areas specific to the assignment described. Students' ability to analyze a specific scenario was reflected in results from the assignment and their ability to synthesize and evaluate the future application of these content areas was reflected in the minute papers. Specific topic integration was primarily the responsibility of the individual pharmacy student, although the entire assignment was designed for this purpose. Students evaluated the case presented by the faculty members and synthesized their own connection points.

Based on anecdotal observations, requiring completion of an integrated assignment caused initial anxiety in some students. Upon launch, some students expressed concerns about being pulled out of their content "silos" worrying that their performance on issues specific to one course would negatively affect their grade in the other course. Ultimately, the students were pleasantly surprised that content integration on the assignment proved to be a positive experience, and responses on student surveys reflected their appreciation for how the project encouraged learning in a practical context. Students also expressed increased confidence in their abilities to apply pharmaceutics topics such as tonicity and excipient functionality, and additionally reported increased ability to transfer the mechanism used to understanding these specific topics to other concepts outside the scope of the assignment. Ultimately these results seem to have demonstrated that coordinated emphasis of topics lead to better appreciation for the relevance of pharmaceutics as a science that enables patient-centered care.

This study is not without limitations with respect to general findings. Because assignment grades were well above the overall aggregate averages for either course, some students may have overestimated their perceived understanding of the material, which may be reflected in the impact of beliefs. The authors also recognize that a single, common assignment spanning a month creates the potential for collaborative learning to occur. To account for this, students were told that specific questions on the final examination would be drawn from concepts addressed during the assignment. Additionally, the Blackboard testing interface was used to randomly vary the numerical values used in all calculation questions (within reasonable limits) from one student to the next.

The internal validity of the innovation may have been impacted by a change in the student selection and admission process. Three years prior to this assessment, the school had transitioned from a 0-6 to a 2-4 program. The current year's class was the first to have entered the new program, which required the addition of an interview process; however, the prerequisite coursework did not change. While this change might have impacted individual students, the impact that this change has had on the student body overall is not yet apparent. Data on the academic characteristics of the 2 classes was not available for comparison. However, the median pharmaceutics final

examination scores between the study year and the previous year were similar: 76.4% ±12.4% and 75.5% ± 11.6%, respectively.

Finally, comparisons of final examination questions for the previous year with those for the study year were likely biased by the amount of time spent focusing on the specific topics during completion of the crossover assignment relative to the previous year. Every topic covered by the 2 courses could not be given the amount of attention given to the case topic; however, the data suggest that students' overall performance in the course in the study year was not negatively impacted by the focus on the crossover assignment.

CONCLUSIONS

A novel crossover assignment used to bridge the concepts between introductory courses in pharmaceutics and pharmacy practice was an effective method of horizontal curricular integration. Integration of this kind had a positive impact on student beliefs pertaining to the relevance of pharmaceutics in pharmacy practice. Additionally, it demonstrated the ability to improve transferability of knowledge within a course. The impact of this innovation on student learning of content also was significantly improved.

REFERENCES

1. Accreditation Council for Pharmacy Education. Accreditation Standards and Guidelines for the Professional Program in Pharmacy Leading to the Doctor of Pharmacy Degree. http://www.acpe-accredit.org. Accessed February 15, 2011.
2. Yanchick VA. Thinking off the map. *Am J Pharm Educ.* 2008;72(6):Article 141.
3. Brown B, Skau K, Wall A. Learning across the curriculum: connecting the pharmaceutical sciences to practice in the first professional year. *Am J Pharm Educ.* 2009;73(2):Article 36.
4. McCall RP. Relevance of physics to the pharmacy major. *Am J Pharm Educ.* 2007;71(4):Article 70.
5. Vaughn L. A conceptual framework for defining pharmaceutical diagnosis. *Am J Pharm Educ.* 1997;61(1):12-18.

Appendix 1. Crossover assignment intended to integrate pharmaceutics and pharmacy practice course concepts.

PHCE 360 & PHPR 381 **Cross-Over Homework Assignment** **Dr. Ira Buckner**
Dr. Peter Wildfong
Dr. Autumn Runyon

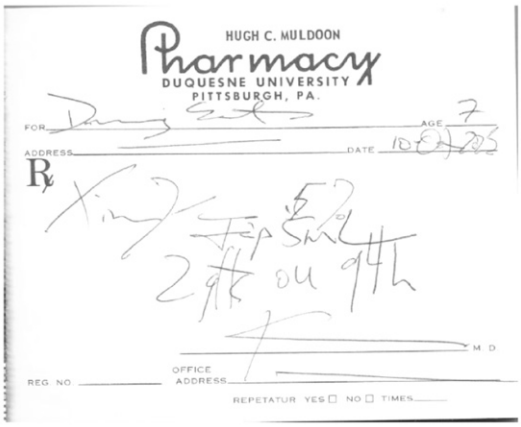
The following case and subsequent questions comprise the *"Cross-Over Homework Assignment"* listed in your syllabi for both Pharmaceutics and Pharmacy Practice I. Our objective is to link concepts from both of these courses to reinforce important topics. Please read the case carefully, and **answer the questions via the Blackboard link by Friday, November 13th at 9:00 am.** The Blackboard link is available through the course site for PHCE 360 in the Assignments section. **No late submissions will be accepted.**

You have been approached by a lawyer to serve as an expert witness in a court case where the plaintiff is the family of a child who experienced pain and loss of vision as a result of a medication error. The plaintiff is suing the pharmacist who dispensed the drug, the pharmacy, and the physician who prescribed it. The following case is provided to you for review.

Background

Sally Smith took her son Danny to his pediatrician for symptoms of an eye infection. The physician diagnosed Danny with Bacterial Conjunctivitis and wrote out the prescription below:

Exhibit A



The physician instructed the mother to place 2 drops into the affected eye, q4h. She left the doctor's office and took the prescription to the local "Med-Rite" pharmacy. She left the pharmacy and asked her husband to pick up the prescription on his way home from work. That evening, Sally placed the drops in her son's eyes as the doctor instructed. Immediately, her son started screaming that the drops burned. Thinking her son was over-reacting, Sally continued using the drops for 2 days, but when her son complained of vision changes, she contacted the doctor who prescribed it. At this point the doctor realized that she was putting otic drops into her son's eye.

Doctor's Deposition

"When Mrs. Smith brought her son to my office, we saw him as an emergency visit. We were able to squeeze him in, but I was running behind at that point in the day and felt rushed when I saw him. I usually prescribe Erythromycin drops for bacterial conjunctivitis, but with his history of an allergic reaction to azithromycin, it wasn't safe to use. I knew there was a product on the market that contained *"Duqacillin"* so I quickly looked in my PDR, and seeing that there was a solution available, I ordered it. I am certain that I wrote for the 0.5% ophthalmic solution! It was 3 days later when I received a call from Mrs. Smith. She read the name of the prescription off the bottle and when I heard her say "otic" I knew why Danny was in such pain: the pharmacist filled the wrong drug! Unfortunately, this caused a permanent impairment of his vision. He is legally blind in one eye and will require corrective lenses for the other. "

Pharmacist's Deposition

"Mrs. Smith dropped off the prescription and I immediately questioned the ophthalmic use of an otic product, so I checked the package insert. The ingredients looked pretty similar to the ophthalmic product with the exception of a couple fillers, so I dispensed it. I figured the doctor knew something special about the drug that I didn't. A few days later the doctor called me and told me that we dispensed the "wrong drug." I told him that I dispensed exactly what he wrote for!"

Exhibit B

The formulations for the two drug products are provided below:

Xinfectear ophthalmic solution

Active Ingredient:	
Duqacillin	0.5% (E value will be given in Blackboard)
Non-medicinal Ingredients:	
Boric acid	0.5%
Sodium bisulfite	0.2%
Tyloxapol	0.25% (E value will be given in Blackboard)
Benzalkonium chloride	0.5 %
Sodium chloride	q.s.

Xinfecdrop otic solution

Active Ingredient:	
Duqacillin	5% (E value will be given in Blackboard)
Non-medicinal Ingredients:	
Boric acid	0.5%
Sodium bisulfite	0.2%
Polysorbate	0.2 % (E value will be given in Blackboard)
Benzalkonium chloride	0.5 %

Appendix 2. Comparison of questions from 2008 and 2009 pertaining to tonicity and formulation of otic and ophthalmic products.

Final Exam Questions 2008

An ophthalmic solution containing two API is prepared according to the following formulation:

Compound	% (w/v)	$\Delta T_f^{1\%}$
Dipivefrin·HCl	0.05%	0.09
Scopolamine·HBr	0.03%	0.07
NaCl	q.s.	0.58
Purified Water, USP	q.s. to 100 mL	

Excipients are classified based on the functional role(s) that they play in a formulation. Based on the formulation above, suggest **two** classes of excipient that are missing from this ophthalmic solution, accompanied by a brief (but accurate) description of the consequence(s) of its absence from the formulation.

(i) Excipient Class:_____

Consequence of Absence from Formulation:

(ii) Excipient Class:_____

Consequence of Absence from Formulation:

Based on the formulation above, will the vapour pressure of this solution be ***higher*** or ***lower*** than that of water?

Final Exam Questions 2009

A formulation for *Phenylephrine*·HCl *2.5% Sterile Ophthalmic Solution, Preservative-free* is prescribed as sterile eye drops for human use. Given a total solution volume of 100 mL, the following components should be added:

Component	Amount	Functional Description
Phenylephrine·HCl	250 mg	*API adrenergic agent, mydriatic*
Polyvinyl alcohol	1.4 g	*Viscosifier*
Edetate Disodium	50 mg	*Antioxidant*
Sodium acetate (anhydrous)	100 mg	
Sodium phosphate, monobasic	100 mg	
Sodium phosphate, dibasic (anhydrous)	50 mg	
Water, Sterile for Injection (preserv.-free)	*q.s.*	*Base; vehicle*

Collectively, the sodium acetate (CH_3COONa), monobasic sodium phosphate (NaH_2PO_4) and dibasic sodium phosphate (Na_2HPO_4) serve what functional role in this formulation?

The polyvinyl alcohol is present in this formulation to increase the overall viscosity of the solution. Briefly discuss why this is important for ophthalmic drug delivery.

The edetate disodium is listed as an antioxidant in this formulation, yet the formulation is specifically referred to as "Preservative-free." The edetate disodium is meant to preserve the formulation against? **Chemical Changes Physical Changes Biological Changes**

The prescription for this formulation includes the following physician instructions: **"2 gtts ou q4h"** Even if written legibly, what medication error(s) could occur according to this nomenclature?

A physician orders a solution to be administered, 2gtts ou q4h prn. The pharmacist prepares an ophthalmic solution with a tonicity of 0.9%. The patient uses the drops in their eyes. Which of the following statements is true?

a. This is an example of a compounding error.
b. This is an example of an error that occurred due to lack of education of the patient.
c. This is an example of a prescribing error.
d. There is no error apparent in the above scenario.