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Research article

Scaffolded online learning modules for milliequivalency and milliosmolarity

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Abstract

Objective: To improve student learning with the use of scaffolded online learning modules that address underlying concepts and mathematical procedures related to milliequivalency and milliosmolarity.
Design: Two online learning modules were created centering on the concepts necessary to calculate milliequivalency and milliosmolarity. Concepts were scaffolded so that students first reviewed elements of the equations individually, next were walked through example calculations, and finally attempted the calculations on their own. Each module opened for students prior to the class in which that topic was covered. An in-class lecture followed the self-paced online modules.
Assessment: Exam scores from the present study were compared to exam scores from a previous year. Only scores on questions that were identical in both years were compared. Students were surveyed to better understand their use of and reactions to the self-paced modules.
Conclusions: A chi-square test revealed that overall students who used the scaffolded modules did significantly better on the exam than students who did not use the modules, χ^2 (1, N = 1832) = 68.48, p = 1.27E−16. In looking at the individual questions (four total), the chi-square test resulted in a significant difference in two. Both of these were milliequivalency questions—in the first question, χ^2 (1, N = 458) = 38.30, p = 6.08E−16, and in the second, χ^2 (1, N = 458) = 39.91, p = 2.66E−16. Based on student survey feedback, students were in favor of these self-paced modules as preparation for the calculations they would have to perform in class and in exams.

Keywords: Scaffolding; Cognitive flexibility theory; Milliequivalency; Osmolarity

Introduction

Knowledge of pharmaceutical calculations is essential to the pharmacy profession, where there is little to no margin for error when performing calculations necessary for optimal patient care. The ability to accurately complete pharmaceutical calculations is paramount to the role of the pharmacist across all health care settings. These calculations may be as straight-forward as calculating a dose for a patient based on weight or as complex as those used to determine patient-specific pharmacokinetic drug parameters. Calculations associated with the compounding of both sterile and non-sterile preparations can be multilayered and require that the pharmacist understand how the calculations impact patient outcomes.

Chapter 797 of the United States Pharmacopeia–National Formulary (USP–NF) sets standards for the compounding of sterile preparations including the completion of accurate calculations. Moreover, USP–NF has an entire chapter dedicated to pharmaceutical calculations in pharmacy practice; chapter 1160.[1] This document addresses the calculations necessary to dose medications, express concentrations, determine product stability and beyond use

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dates, and apply the concepts of milliequivalency and osmolarity to the patient care setting.

The Accreditation Council on Pharmaceutical Education (ACPE) Competencies[2] addresses the importance of pharmaceutical calculations in pharmacy education in Appendix 1—required elements of the didactic doctor of pharmacy degree and the importance of effective and appropriate teaching and learning methods in Standard 10. According to ACPE, one of the performance competencies for pharmacy students under the core domain of patient safety is using accurate calculations to compound parenteral and non-parenteral drug products. Additionally, the North American Pharmacist Licensure Examination (NAPLEX) Competency Statements[3] also emphasize the need for the skill of accurate calculations in Area 2—assess safe and accurate preparation and dispensing of medications.

The importance of accurate drug calculations is further evidenced by the research in pharmacy education that investigates improvements in the teaching and learning of pharmaceutical calculations,[4–15] much of which centers on the use of technology.[4–9] In a 2007 survey of 72 colleges and schools of pharmacy, half of those reported that their institution requires students take a course specifically focused on pharmaceutical calculations.[10] Clearly, there is recognition not only that this is a necessary skill, but also that attention should be paid to how we might improve student knowledge gains in this area.

The need for improvement stems from the fact that milliequivalents and osmolarity are often some of the more difficult topics for students due to the complex nature of the concepts and equations needed to perform calculations. The calculations often require multiple steps and conversions resulting in many opportunities for error. Not only is it important for students to understand how to perform the calculations but also it is important that they know how their answers impact the care of patients. Osmolarity calculations are important for understanding how the infusion of an intravenous preparation will impact the osmotic pressure of bodily fluids and potentially the fluid-electrolyte balance in the body.[16] Osmolarity is reported in terms of milliosmoles (mOsm)/liter or mOsm/L. The total number of mOsm may also be reported without reference to a solvent. Milliequivalents are the units used to measure the amount of electrolytes in a solution, taking into account the valence or chemical combining power of the electrolyte.[16] It is the unit of measure most commonly used to report blood plasma concentrations of electrolytes.

The purpose of this study was to investigate the effect of scaffolded online modules on students' ability to calculate milliequivalents and osmolarity. While students are expected to come to the course with a basic understanding of the underlying concepts and mathematical operations for these equations, many still struggle. This had two somewhat polar consequences in past years (1) the professors would spend extra class time remediating on the concepts, forcing them to fall behind, or (2) the professors pushed forward with the equations with the expectation that students would remediate on their own. The scaffolded online modules were open to the students prior to the scheduled lecture so that class time could be better allocated to work through cases, perform calculations, and discuss patient care implications. Two scaffolded online modules (one on milliequivalents and one on osmolarity) were created using a content authoring tool (Softchalk® 9.01.07, Richmond, VA). In the past, students struggled with the equations because they forgot or had difficulty connecting the basic concepts underlying the elements of the equations. In order to remediate on these concepts, self-paced modules were created based on scaffolding and cognitive flexibility theory.

Scaffolding is an instructional tool used to provide learning supports to students where necessary, with the goal of slowly removing these supports until the learner becomes more able. Wood et al.[17] introduced scaffolding as a "process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts."[17] The present study used the following elements of scaffolding: "reduction in degrees of freedom" where a task is initially simplified, "marking critical features" where relevant aspects of the task are made obvious, and "demonstration" where the task is modeled. Scaffolding has also been used in other areas of pharmacy education including communication[18] and critical evaluation of literature skills.[19]

Once the scaffolding of the task brings the student to a place where they are capable of performing that task on their own, it is important that the student be able to apply or transfer that knowledge across multiple scenarios or cases. Spiro et al.[20] call this "cognitive flexibility." "Straight forward, linear instruction in the form of tutorials, lectures, and many other formats will, according to cognitive flexibility theory, fail to accomplish important educational objectives in part because of oversimplification of the material presented. This oversimplification results in the inability to transfer knowledge across to new and varied domains."[20] We aimed to avoid this linear type of instruction. Much of the work in cognitive flexibility theory resides in the world of technology-aided instruction as hypertext that lends itself well to the kinds of flexible thought and application necessary to transfer knowledge from one problem to another. This led us to create online modules that provided students the opportunity to apply the underlying concepts to the varying cases and therefore forms of calculations students would face in their profession. In the online modules, students were able to navigate non-linearly between the equation problems, background information on concepts, and process instructions for solving the equations.

Design

The Pharmacy Skills Lab course at Albany College of Pharmacy and Health Sciences (ACPHS) runs every year