American Journal of Pharmaceutical Education **2015; 79 (2) Article 24.**

INSTRUCTIONAL DESIGN AND ASSESSMENT

The Impact of Blended Learning on Student Performance in a Cardiovascular Pharmacotherapy Course

Jacqueline E. McLaughlin, PhD, MS,[a] Nastaran Gharkholonarehe, PharmD,[b] Julia Khanova, PhD,[a] Zach M. Deyo, PharmD,[a] Jo E. Rodgers, PharmD[a]

[a] University of North Carolina at Chapel Hill Eshelman School of Pharmacy, Chapel Hill, North Carolina
[b] REX UNC Health Care, Raleigh, North Carolina

Submitted March 19, 2014; accepted July 8, 2014; published March 25, 2015.

Objective. To examine student engagement with, perception of, and performance resulting from blended learning for venous thromboembolism in a required cardiovascular pharmacotherapy course for second-year students.
Design. In 2013, key foundational content was packaged into an interactive online module for students to access prior to coming to class; class time was dedicated to active-learning exercises.
Assessment. Students who accessed all online module segments participated in more in class clicker questions ($p=0.043$) and performed better on the examination ($p=0.023$). There was no difference in clicker participation or examination performance based on time of module access (prior to or after class). The majority of participants agreed or strongly agreed that foundational content learned prior to class, applied activities during class, and content-related questions in the online module greatly enhanced learning.
Conclusion. This study highlights the importance of integrating online modules with classroom learning and the role of blended learning in improving academic performance.
Keywords: pharmacotherapy, blended learning, active learning, clickers, cardiology

INTRODUCTION

Despite significant changes in health care and education in recent years, classroom practices continue to be dominated by instructor-delivered lectures in class. More than 30 years of research point to the limitations associated with unidirectional learning via in-class lectures, including lack of student attention and limited opportunities to develop essential skills.[1-3] A growing body of literature highlights the need to rethink our approach to classroom learning and describes pedagogical innovations that foster higher-order thinking, improve information analysis and learning skills, and enhance opportunities for active and applied learning.[4-6] These approaches represent an ongoing paradigmatic shift in education from teacher-centered instructional strategies (eg, lecturing) to learner-centered instructional strategies (eg, active student engagement).[7]

Corresponding Author: Jo E. Rodgers, PharmD, UNC Eshelman School of Pharmacy, University of North Carolina at Chapel Hill, CB 7569, 3201 Kerr Hall, Chapel Hill, North Carolina 27599. Tel: 919-962-2249. Fax: 919-962-0644. E-mail: jerodgers@unc.edu

Blended learning is a learner-centered approach that integrates traditional face-to-face learning with a computer-mediated learning environment.[8-9] As an example, students are provided with foundational content to learn prior to class so that class time can be dedicated to active-learning exercises, such as automated response system (ARS, or "clickers") questions, case-based discussions, and think-pair-share.[10-12] By combining the strengths of computer-mediated instruction (ie, dynamic digital interfaces, embedded assessments, data analytics, self-paced content acquisition) and face-to-face class time (ie, faculty member and peer engagement, hands-on applied learning), blended-learning environments can produce improved student outcomes and facilitate acquisition of competencies that may not otherwise be achieved.[9,13-15] This approach can increase student engagement with the learning process, enhance critical-thinking development, and improve learning outcomes.[16-19]

Evidence from a wide range of disciplines supports the use of blended learning to improve student outcomes.[20-23] Improvement in student outcomes associated with blended learning can be described, in part, by constructivism, which views knowledge not as a finite and defined body of facts and concepts, but as ever-evolving and dynamically constructed by the learner in interaction with others and with the environment.[24-27] In teaching practice, the constructivist view of learning promotes utilization of active learning to engage students in the learning process through meaningful activities that prompt them to reflect on ideas, self-assess content mastery, gather information, and apply it to solving problems.[28-30] This theoretical approach also emphasizes the importance of information resources and tools linked to the learning environment and made available to students prior to class in order to facilitate independent, self-paced knowledge building and development of thinking skills with self-assessment opportunities.[31]

There is limited research to date on how student pharmacists construct knowledge using different elements of the blended learning environment within a pharmacotherapy course. Pierce and Fox reported improved performance and perceptions associated with video podcasts and case-based discussions in a renal pharmacotherapy module,[16] while Crouch reported improved class preparation and positive student perceptions in a blended advanced cardiovascular pharmacotherapy elective course.[32] However, data describing student engagement with online material and in-class, active-learning exercises, as well as the relationship between these variables and academic performance, were not reported. Given the complex nature of knowledge in cardiovascular pharmacotherapy and the ability of blended learning to improve outcomes, the investigators hypothesized that engagement with interactive online foundational content prior to class would be positively related to engagement during class time and performance on the examination. Additionally, in recognition that academic performance can be influenced not only by the learning content and instructional methods but also by students' perception of the learning environment,[33] student satisfaction and perceived impact of the instructional model on learning were assessed with the expectation that blended learning would be well received by the students.[16,32]

DESIGN

Pharmacotherapy 444 is a required course for all second-year pharmacy students enrolled in the doctor of pharmacy (PharmD) program at the University of North Carolina (UNC) Eshelman School of Pharmacy. A physiology prerequisite is offered in the first year of the program. The content covered in the prerequisite course is basic physiology (eg, blood flow through heart chambers, electrical conduction through the heart) and is not disease specific. In addition, a medicinal chemistry course sequence runs concurrently with the pharmacotherapy course, and timing of content is coordinated between the 2 courses (eg, heparin medicinal chemistry covered within same week). A separate pharmacology course does not exist. Thus, all disease-specific pathophysiology, as well as all pharmacology is embedded in the pharmacotherapy course. Venous thromboembolism (VTE) is covered in a 2-class period sequence that integrates the pathophysiology of cardiovascular disease, pharmacology of intravenous and oral anticoagulants, and applied therapeutics. For more than a decade, VTE material was delivered using a traditional lecture-based format. In the spring of 2013, both VTE class periods were redesigned and implemented using a blended-learning format. All key foundational content was packaged into an interactive online module that students had access to prior to coming to class. The module was comprised of 57 annotated slides (divided into 7 segments) that included a pretest and embedded self-assessments at the end of each segment (posttest). The online module was developed by the school's Educational Technology, Research, and Development Group, who transformed an initial set of PowerPoint slides using a combination of software, including Adobe Master Suite version CS6 (Adobe Systems, Acrobat, San Jose, CA) and MySQL Release 5.8 (Oracle Corporation, Redwood Shores, CA). Figure 1 illustrates one slide from the online module. Completing the online module prior to coming to class was highly encouraged but not mandatory. Module completion took approximately 40 minutes, but varied based on student pace and time spent on each segment in the module. Learning objectives for the online module and the in-class lecture, example premodule and postmodule assessment questions, and example in-class ARS case-based questions are provided in Table 1.

Since foundational content was provided to students prior to class, scheduled class time was devoted to limited didactic lecture and expanded active-learning exercises, including ARS questions and case-based discussions. Two classes were scheduled, each class consisting of two 50-minute periods with a 10-minute break between periods. The ARS questions were asked at the beginning of each class period to assess student mastery of key foundational concepts and provide the instructor with an opportunity to address any misconceptions or gaps in knowledge prior to applying those concepts during case-based discussions. Five ARS questions were used at the start of the first VTE class, and 7 ARS questions were used at the start of the second VTE class. Time devoted to ARS questions and answers was approximately 15 minutes. Following ARS questions, students were engaged with brief periods of lecture blended with case-based discussion (approximately 3-5 cases per hour) for the remainder of class. These cases were selected to demonstrate the application of key foundational concepts to

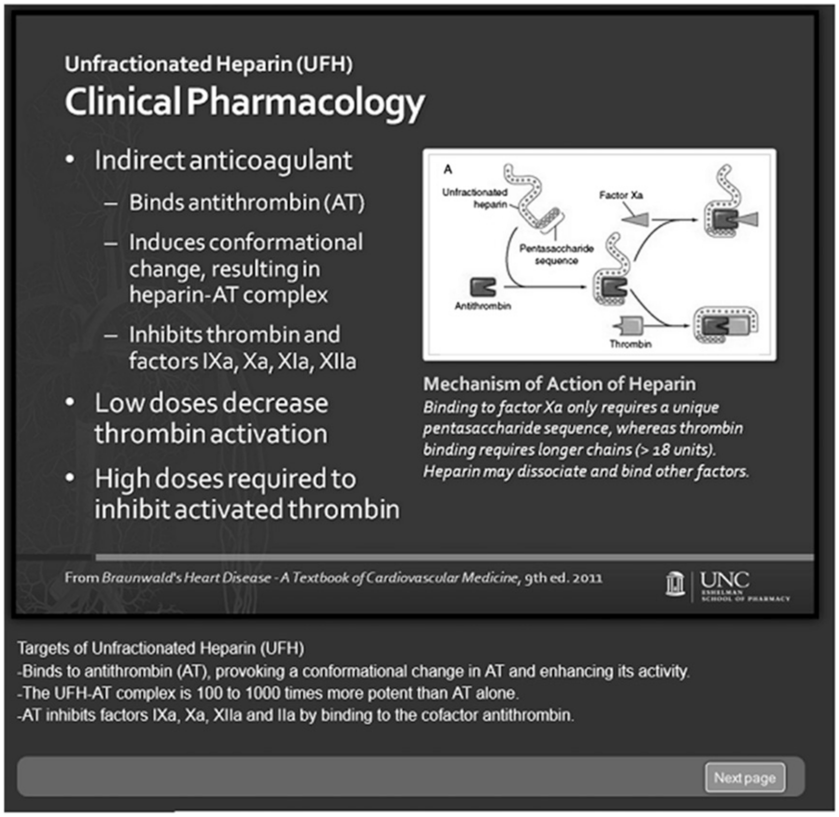

Figure 1. Example Slide from Online Module

real-world pharmacy-based problems and to foster higher-order thinking skills in students. This course was delivered in a large auditorium setting with long rows of stationary tables, and students were not asked to move into groups or change seats during class. A final examination covering the VTE content was administered one week following the VTE course sequence. All ARS questions, premodule and postmodule assessment, and final examination questions were multiple choice. Importantly, only the final examination questions counted for a portion of the final course grade.

With the exception of one other topic, VTE was the only disease topic in this course that used an online module for delivering foundational preclass work, included required embedded assessments in the online module, and applied that foundational content during class using case-based learning and ARS questions, in contrast to other topics that used ARS questions to assess new content delivered during class. The other disease topic with online preclass work utilized a different online format. Use of ARS questions across all disease topics was similar (ie, volume); however, greater time for application occurred during the VTE lecture given related preclass work and assessments.

In spring of 2013, 170 students enrolled in the course. Students were informed of the study via the course syllabus, a brief announcement during class, and an e-mail from the course director. Informed consent was obtained by a co-investigator who was not involved with formal instruction or assessments. The course instructor was not provided with any identifiable information about participants. No incentives were provided for participation in the study. Power analysis calculation with an alpha of 0.05 and beta of 0.8, indicated that a minimum sample size of 85 was necessary to find significance associated with a 10-point difference in examination performance. Ninety-five students consented to participate in the study.

For each participant, data collection included the date that the module was first accessed, responses to the module pretest and posttest, responses to each in-class ARS question, and performance on each VTE examination question. Each of the 12 examination questions was coded as mapped to (ie, explicitly covered) or not mapped to the online module. To assess the relationship between online module engagement and performance in the course, data was recoded for each participant to reflect the percentage of ARS questions answered during class (ARS participation), of ARS questions answered

Table 1. Example Learning Objectives and Questions for Venous Thromboembolism Online Module and Class

Online Module	In-class Lecture
Learning Objectives	Learning Objectives
1) Explain the etiology, pathophysiology, and clinical presentation of venous thromboembolism (VTE)	1) Outline evidence-based strategies for managing VTE prophylaxis and treatment
2) Identify common risk factors associated with VTE	2) Compare and contrast the various anticoagulants used in the management of VTE
3) Outline the basic mechanism of action (clotting factor target) for various anticoagulants used in the management of VTE	3) Describe the practical management of vitamin K antagonist (VKA) therapy
4) Review dosing (treatment and prophylaxis) for various anticoagulants including need for dosage adjustment in select patient populations (eg, renal impairment)	4) Compare and contrast newer oral anticoagulants with VKA therapy Describe the presentation and management of heparin-induced thrombocytopenia
Example Questions	Example Questions
1) (Case provided) - Which of the following are risk factors for developing a venous thromboembolism in this patient? a) Use of oral contraceptives b) Recent immobility c) Obesity d) All of the above	1) (Case provided) - Which of the following would you recommend for VTE prophylaxis in JB? a) IVC filter placement b) IPC device alone c) Enoxaparin 40mg SQ once daily d) Fondaparinux 7.5mg SQ once daily
2) (Case provided) - Which of the following are consistent findings for pulmonary embolism in this patient? a) Tachycardia b) Tachypnea c) Sudden onset shortness of breath d) All of the above	2) (Case provided) - Which of the following would be an acceptable option for VTE prophylaxis in LA? a) UFH 5000 units SQ q8 hours b) Rivaroxaban 20mg PO q24 hours c) Enoxaparin 30mg SQ twice daily d) Answers B and C e) All of the above
3) Which of the following is <u>not</u> a major advantage of LMWH over UFH? a) Less frequent administration b) Less need for monitoring c) Less risk of HIT d) Less need for renal adjustment	3) (Case provided) - Which of the following are options for treatment of LCs PE/DVT? a) Fondaparinux 10mg SQ once daily b) IV UFH 80 units/kg bolus, then 18 units/kg/hr c) Rivaroxaban 20mg PO once daily d) Enoxaparin 120mg SQ twice daily e) All of the above are options
4) Which of the following requires adjustment for both hepatic and renal impairment? a) Rivaroxaban b) Argatroban c) Lepirudin d) Dabigatran	4) (Case provided) - Which of the following would be an acceptable alternative form of initial anticoagulation for JF given a potential diagnosis for HIT? a) Fondaparinux 2.5mg b) Argatroban infusion c) VKA 10mg titrated to INR of 2 to 3 d) None; simply d/c her OCP e) Dabigatran 150mg twice daily

correctly (ARS performance), of examination questions correct (examination performance), of mapped examination questions correct (examination performance for mapped content), and of unmapped examination questions correct (examination performance for content not mapped). In addition, data describing student perceptions of the blended learning elements of the course were collected during the last 5 minutes of the course via ARS questions. All students enrolled in the course had the opportunity to participate in this in-class survey. The UNC Institutional Review Board approved this study.

All data analyses were conducted in SPSS for Windows, Version 20 (IBM, Armonk, NY). All data were determined to be parametric. Paired *t* tests were used to compare responses on the module pretest and posttest. Independent *t* tests were used to compare ARS

Table 2. Comparison of Engagement and Performance Based on Online Module Access

	Accessed All Segments (n=69)	Did Not Access All Segments (n=26)	
	% Mean (SD)	% Mean (SD)	*p* value
ARS Participation	82.6 (22.5)	70.8 (30.7)	0.043
ARS Performance	38.5 (15.6)	35.6 (18.9)	0.442
Exam Performance	78.7 (14.0)	71.2 (14.4)	0.023
Mapped Content	81.7 (13.6)	75.4 (14.2)	0.048
Unmapped Content	71.0 (26.7)	60.6 (29.3)	0.101

participation (%), ARS performance (%), and examination performance (%) for students who accessed all module segments and those who did not access all module segments. For students who accessed all module segments, independent *t* tests were used to compare ARS participation, ARS performance, and examination performance between students who accessed all segments prior the first class of the VTE sequence and students who accessed all segments after the first class. The Pearson rho was used to investigate correlations between continuous variables. Significance was established at $\alpha=0.05$. Continuous data are presented as mean (SD). Likert scale findings are presented as median (range).

EVALUATION AND ASSESSMENT

Online module engagement, ARS participation, ARS performance, and examination performance were collected for all participants (n=95). Participants accessed an average of 5.3 (2.9) out of 7 module segments. When compared to students who accessed all of the module segments (n=69), students who did not access all segments (n=26) participated in fewer ARS questions (82.6 (22.5) vs 70.8 (30.7), $p=0.043$) and scored lower on the examination (78.8 (14.0) vs 71.2 (14.4), $p=0.023$). More specifically, students who did not access all of the module segments scored lower on VTE examination questions mapped to content covered by the online module (81.7 (13.6) vs 75.4 (14.2), $p=0.048$) but no significant difference was found between the 2 groups for examination questions not specifically covered by the online module (Table 2). Students who did not access all module segments accessed an average of 0.8 (1.5) segments.

Data were further examined for students who accessed all module segments (n=69). These students scored significantly higher on the module posttest than they did pretest (60.9 (16.2) vs 53.8 (18.0), $p=0.015$). Module posttest scores were not significantly correlated with final examination performance. When examining the date and time of module access, there was no significant difference in ARS participation, ARS performance, or examination performance for students who accessed the module prior to the first VTE class period (n=26) and those who accessed the module after the first VTE class period (n=43). All correlations examined between online engagement, ARS engagement, ARS performance, and examination performance were weak ($r_p<0.03$).

During the final course period, the students enrolled in the course were surveyed about the new course format using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The survey had an 80% response rate, with 62% of students enrolled in the course agreeing or strongly agreeing that "learning foundational content prior to coming to class greatly enhanced my learning of course material in class" (median 4, range 1-5). Seventy-three percent agreed or strongly agreed that "interactive, applied in-class activities (eg, discussion of cases) greatly enhanced my learning" (median 4, range 1-5), and 56% agreed or strongly agreed that "content-related questions embedded in [online material] greatly enhanced my learning" (median 4, range 1-5).

DISCUSSION

A growing number of pharmacy educators are using blended-learning strategies to foster student development and improve learning outcomes. Better understanding of how elements of a blended-learning environment, such as computer-mediated instruction and in-class active learning, impact student engagement and outcomes is critical for pharmacy educators. In this study, positive impacts associated with student engagement within a blended-learning environment were demonstrated and the resulting student perceptions were reported.

These findings support other pharmacy education studies that describe positive student outcomes associated with student engagement in blended learning.[16-18] Namely, the analysis revealed that engagement with the online module was positively related to engagement in class and positively related to academic performance. Improved scores on the postmodule test indicated that the online module contributed to student understanding of foundational VTE content. A significant relationship between module access and mapped examination questions but not between module access and unmapped examination questions further supported the contribution of the online module to student learning outcomes.

Although module access was positively related to examination performance, there was no relationship found between timing of module access (before or after the class) and ARS performance or between the module posttest and final examination performance. One possible explanation for this finding is that the active learning complimented and reinforced the foundational information in a way that enabled students to further connect, synthesize, and understand complex constructs and ideas. This, in turn, resulted in improved final examination scores and suggests that this process was not time-dependent or order-dependent. This finding is consistent with the constructivist pedagogical theory, which emphasizes the importance of interaction with others in knowledge construction and developing deeper understanding of subject matter.[28-30]

In addition, the blended-learning approach used in this course was generally well received by the students. Specifically, student responses reflected positively on learning foundational content prior to class and using class time for active learning exercises. These findings align with other studies that report positive student perceptions of blended learning in pharmacotherapy.[16,32]

While the results of this study provide support for the use of interactive online tools and active learning exercises to teach cardiovascular pharmacotherapy, there are several limitations to this approach that warrant consideration. First, the workload associated with creating relevant and rigorous web-based content and in-class activities can be substantial. There are various strategies, modalities, and activities associated with blended learning, and numerous factors can impact the feasibility, efficacy, and sustainability of technological interventions.[34] Faculty members should be mindful of the time and resources available when developing and sustaining computer-mediated instructional material so that it is easily modified for subsequent years. Also, while select material may be best offloaded using an interactive web-based approach, this may not be true for all types of materials. Other approaches to engaging students with content outside the classroom should be used as appropriate. In addition, using web-based and computer-mediated approaches require that students have personal access to the appropriate technology and technological support. Finally, this study determined the impact on short-term learning and retention but did not assess the impact on long-term retention. Future studies should assess how various blended-learning approaches impact long-term outcomes. Despite these limitations, the flexibility of blended learning makes it a highly translatable model.

SUMMARY

Pharmacy educators are tasked with preparing aspiring pharmacists to meet the evolving health care needs of society within rapidly evolving education, technology, and health care systems. Advancements in blended learning provide opportunities for educators to implement dynamic methods that actively engage students in the learning process. We conclude that student engagement with online foundational VTE content provided prior to class is positively related to academic performance and in-class engagement. Findings from this study point to the importance of integrating online modules with classroom learning and underscore the role of foundational content delivered prior to class and in-class active learning in improving academic performance.

ACKNOWLEDGMENTS

The authors would like to thank The Carolina Partnership and The Pharmacy Network Foundation, Inc. for generous support of The Academy and the Educational Renaissance Initiative at the UNC Eshelman School of Pharmacy. This project would not have been possible without the expertise and dedication of The Academy at the UNC Eshelman School of Pharmacy and the school's Educational Technology, Research & Development Group. The authors would like to thank all members of the Educational Technology Research & Development Group, including Christopher Davidson, Jason Whitley, Catherine McAllister, and Larissa Biggers. The authors would also like to acknowledge Dr. LaToya Griffith for contributions to data management and analyses.

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