Learner Satisfaction and Quality of Student-Faculty Interactions in Traditional vs. Blended Classrooms

Dr. Brian P. Helmke, University of Virginia

Brian Helmke is currently Associate Professor of Biomedical Engineering at the University of Virginia. He received the B.S.E. in bioengineering from the University of Pennsylvania, the B.S.Econ. from The Wharton School of the University of Pennsylvania, and the Ph.D. in bioengineering from the University of California, San Diego. Brian's research interests include cardiovascular physiology, cellular mechanobiology, and nanotechnology-based biomaterials. He is also interested in technology-enhanced teaching and in experiential learning for undergraduates in science and engineering.

Dr. William H. Guilford, University of Virginia

Will Guilford is an Associate Professor of Biomedical Engineering at the University of Virginia. He is also the Undergraduate Program Director for Biomedical Engineering, and the Director of Educational Innovation in the School of Engineering. He received his B.S. in Biology and Chemistry from St. Francis College in Ft. Wayne, Indiana and his Ph.D. in Physiology from the University of Arizona. Will did his postdoctoral training in Molecular Biophysics at the University of Vermont under David Warshaw. His research interests include novel assessments of educational efficacy, the molecular basis of cell movement, and the mitigation of infectious diseases.

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The effectiveness of active learning methods to improve learning in STEM higher education has become an area of national interest, in part because of a perceived need to increase retention of students in STEM careers and support their career development in a global economy [1]. Support for designing courses with a variety of activities to increase student engagement is based on evidence of increased test scores and reduced failure rates in active learning classrooms in a variety of disciplines [2]. Even though active learning strategies such as peer instruction have been demonstrated to improve scores on these traditional assessments (tests), it is not clear whether student perceptions of their learning environments are positive [3]. In fact, students often become frustrated with or demonstrate resistance to some active learning course designs [4], [5]. Thus, it is reasonable to question whether active learning approaches encourage or discourage student persistence in STEM.

One of the most important factors in supporting student career development in STEM fields is the level of direct faculty involvement in guiding students' learning [6]. One educational strategy involves limiting student enrollment in order to maintain a high level of student-faculty interactions both inside and outside the classroom. For example, large enrollment core classes may be split into sections with smaller class sizes, which many propose is "better" in part because it enables increased faculty-student interactions and affords an opportunity for incorporating evidence-based active learning practices. However, strategies for optimizing the educational approach and quantifying better outcomes are not always clear.

Better outcomes associated with specific pedagogical strategies are often interpreted to mean improved retention, recall, and comprehension. However, we previously showed that active learning and traditional approaches achieved similar learning gains in a course in physiology for engineers [7]. Since these learning gains represent only one way to evaluate outcomes, they do not necessarily reflect other aspects of the classroom such as learner satisfaction or quality of student-faculty interactions. The goal of this study was to ask whether a blended learning environment based on low-stakes formative assessments improves students' satisfaction with the learning environment and quality of student-faculty interactions.

Research Methods

Course descriptions

Two sections of a sophomore-level physiology course in biomedical engineering were taught in the same semester by two different instructors, as reported previously [7]. Both sections required reading assignments from the *Guyton and Hall Textbook of Medical Physiology* [8] in topic areas that included electrical excitability of cell membranes, muscle contraction, cardiac physiology, vascular physiology, and respiratory physiology. Each section was divided into four units of 3-4 weeks duration that ended with a summative exam.

One course section (Control, traditional, 86 respondents) was taught using traditional lectures with slides and interactive demonstrations. Class recordings and copies of slides were posted to the course web page and available to students immediately after each class. Evaluation consisted of a weekly quiz in addition to the unit exams, and students were credited with the higher of their mean quiz grade or their exam grade. Students could opt out of taking the exam if they were satisfied with the grade earned from quizzes. The timing of the quizzes was chosen to elicit the "testing effect" [9] in a manner to that described by others [10].

The second course section (Intervention, blended, 39 respondents) was taught using a blended learning format based around interactive lectures and frequent formative assessments in addition to the quarterly unit exams. The quarterly exams tested the same concepts as those in the Control section and included identical questions. Students participated in several types of low-stakes formative assessments. Daily in-class activities included interactive lecture, think-pair-share activities, team-based worksheets, and audience-response questions. Online "flashcard" quizzes paired with each class session were designed to give practice with common vocabulary, physiological values, and key concepts. Finally, online weekly practice quizzes included practice test questions. These low-stakes assessments were lightly graded. Finally, teams of students also completed quarterly medium-stakes "exploration activities" that encouraged students to recognize mechanistic relationships and to relate concepts from the course to their career interests.

Survey instrument

Students completed an end-of-course survey that contained Likert-type and open-ended short answer questions about the learning environment and contributions of class activities to learning, learner satisfaction, and the quality of faculty-student interactions. For Likert-type questions, student answers were encoded on a five-point scale as "strongly disagree" (1 point), "disagree" (2 points), "undecided" (3 points), "agree" (4 points), and "strongly agree" (5 points).

Statistical analysis

Likert-scale responses were encoded on a scale of 1 (strongly disagree) to 5 (strongly agree). Mean scores were compared using the unpaired *t*-test. Effect sizes were estimated using Hedge's *g* to adjust for unequal sample sizes between the class sections. For analysis of multiple survey questions mapped to learner satisfaction and faculty-student interactions categories, Likert scores were summed before comparison. In these categories, Cronbach's alpha was computed to evaluate reliability.

Results

Learning Environment

Students responded to eight Likert-type questions designed to assess their perceptions of the learning environment in each class section (Table 1).

Table 1. Learning environment and contributions of class activities to learning. Mean ± SD for 5-point Likert scale; p-value for t-test comparing Intervention to Control; Hedge's g to measure effect size.

	Mean ± SD	*p*-value	Hedge's *g*
Overall, the learning environment in this course was supportive and helped me learn.			
Control	4.40 ± 0.81		
Intervention	3.84 ± 1.04	0.002	0.62
The textbook assignments helped me learn.			
Control	2.87 ± 0.97		
Intervention	3.56 ± 1.08	0.0006	0.69
In-class lectures helped me learn.			
Control	4.67 ± 0.71		
Intervention	4.13 ± 0.82	0.0003	0.73
In-class discussions and Q&A helped me learn.			
Control	4.15 ± 0.81		
Intervention	4.37 ± 0.53	0.08	0.27
The weekly quizzes helped me assess my progress learning the course content. (Control) Practice Quizzes and Flashcard Quizzes helped me prepare for the tests. (Intervention)			
Control	4.07 ± 0.96		
Intervention	4.44 ± 0.71	0.02	0.41
The (graded) quizzes/tests helped me assess my progress learning the course content.			
Control	3.35 ± 0.96		
Intervention	3.82 ± 0.87	0.01	0.51
The structure of this course encouraged me to explore outside resources to help me learn.			
Control	3.64 ± 0.90		
Intervention	3.95 ± 0.75	0.07	0.36
I can relate what I learned in this course to other courses, my career interests, and topics in the fields of biomedical engineering and medicine.			
Control	4.53 ± 0.66		
Intervention	4.38 ± 0.74	0.26	0.22

Students in the Control section (traditional format) gave significantly higher scores to the overall learning environment ($p = 0.002$, $g = 0.62$) and to the lectures ($p = 0.0003$, $g = 0.73$) as tools for learning course material.

Students in the Intervention section (blended learning format) gave significantly higher scores to the helpfulness of the textbook for learning ($p = 0.0006$, $g = 0.69$), the usefulness of weekly quiz activities ($p = 0.02$, $g = 0.41$), and the helpfulness of graded tests for self-assessment ($p = 0.01$, $g = 0.51$). It is important to note that the wording of the questions regarding weekly quizzes was different between the two class sections because of the difference in purpose of the activities. In the Control section, weekly quizzes were graded. In contrast, quizzes in the Intervention section

Table 2. Learner satisfaction. Mean ± SD for 5-point Likert scale; p-value for t-test comparing Intervention to Control; Hedge's g to measure effect size.

	Mean ± SD	*p*-value	Hedge's *g*
I liked the teaching style and learning environment in this course.			
Control	4.40 ± 0.70		
Intervention	3.77 ± 0.80	0.00003	0.85
I am satisfied with how well/how much I learned in this course relative to my level of effort towards learning.			
Control	4.33 ± 0.83		
Intervention	3.85 ± 1.05	0.007	0.53
I am satisfied with the number and quality of opportunities to assess my own understanding and learning that I received in this course.			
Control	3.90 ± 0.95		
Intervention	3.90 ± 0.81	0.99	0.002
Total			
Control	12.6 ± 1.9		
Intervention	11.5 ± 2.0	0.004	0.57

were "lightly graded" formative assessments; students could take the quizzes multiple times and received the highest of their scores.

Students' scores of the helpfulness of in-class discussions and Q&A activities was not significantly different between the two class sections. Scores were also not different when rating how well the structure of the course helped to explore outside resources for learning and when rating how well learning in the course relates to other courses, career interests, and the field of biomedical engineering.

An open-ended question asked students to identify specific activities and aspects of course structure that helped their learning in the course. Students in the Control section mentioned most often the class recordings (29 of 137 individual items mentioned by 86 responders), lectures (20), shared slide decks (19), weekly quizzes (19), and in-class Q&A activities (17). In the Intervention section, the most frequent answers were online flashcards (23 of 94 individual items mentioned by 39 responders), weekly practice quizzes (20), team-based exploration activities (16), in-class interactive questions (9), and class recordings (7).

Learner Satisfaction

Students responded to three Likert-type survey questions designed to assess how well they liked the teaching style and learning environment in the course (Table 2). Average Likert scores and total score were compared between the sections. Cronbach's alpha was computed to assess internal consistency among the questions for assessing learner satisfaction (Control, 0.67; Intervention, 0.57).

Both individual scores and the total score indicated that students in the Control section had significantly higher satisfaction levels with the teaching style, learning environment, and quantity of learning relative to effort than in the Intervention section. Satisfaction with the opportunities for self-assessment was not different between the two sections.

An open-ended question asked students to reflect on their level of satisfaction with their own learning and achievement in the course. Most students in both sections indicated that they were satisfied with their learning (Control, 72 of 112 individual comments by 79 responders; Intervention, 29 of 62 individual comments by 39 responders). Some students indicated that they were not satisfied with their achievement in the course despite their satisfaction with their perceptions of their own learning (Control, 26 comments; Intervention, 15 comments). In addition, a few students were not satisfied with their learning (Control, 2 comments; Intervention, 4 comments). Interestingly, some students' comments indicated that they experienced personal growth associated with study habits and learning how to learn during the course (Control, 7 comments; Intervention, 11 comments).

Faculty-Student Interactions

Students responded to five Likert-type survey questions regarding their perceptions of the quality of faculty-student interactions during the course (Table 3). Average Likert scores and total score were compared between the sections. Cronbach's alpha was computed to assess the internal consistency among the questions for assessing faculty-student interactions (Control, 0.83; Intervention, 0.72).

Students' perceptions that the class structure encouraged them to interact with their instructors scored significantly higher in the Control than in the Intervention class section. Supportiveness of interactions, accessibility of the instructor, and quality of feedback were not different between the two sections.

Discussion

In traditional classroom styles, improvements in learning associated with the "testing effect" occur with repetition of higher stakes assessments that reinforce retention and recall [9], [10]. Interestingly, well-structured low-stakes formative assessments designed for frequent practice enable increases in retention and recall to a similar level as is achieved with the testing effect [7]. Despite learning gains associated with an active or blended learning class format, students may demonstrate resistance and frustration with active learning approaches [4], [5]. Student resistance is linked to factors such as a preference for traditional lecture-homework-test formats [4]. Another possibility is that the course style influences learner satisfaction and the quality of student-faculty interactions. Smaller class size and active learning approaches are typically thought to improve these aspects of the student experience. In order to test this hypothesis, we compared students' feedback in a blended learning physiology class to that in a more traditional classroom style.

Students in the class section with traditional style (Control) appeared to be more satisfied with the overall learning environment in the class, and they found the lectures and associated

Table 3. Faculty-Student Interactions. Mean ± SD for 5-point Likert scale; p-value for t-test comparing Intervention to Control; Hedge's g to measure effect size.

	Mean ± SD	*p*-value	Hedge's *g*
The structure of this course encouraged me to interact with my instructor and teaching assistants.			
Control	4.13 ± 0.76		
Intervention	3.74 ± 0.81	0.01	0.50
I am satisfied with the level and quality of student-instructor interactions in this course.			
Control	4.15 ± 0.76		
Intervention	4.18 ± 0.71	0.84	0.04
Student-instructor interactions in this course were supportive and helped me learn.			
Control	4.16 ± 0.74		
Intervention	4.28 ± 0.64	0.39	0.17
The instructor was readily accessible when I needed help with my learning.			
Control	4.09 ± 0.83		
Intervention	4.28 ± 0.55	0.20	0.35
I am satisfied with the amount and quality of feedback about my progress toward course objectives that I received in this course.			
Control	3.66 ± 0.87		
Intervention	3.59 ± 0.95	0.68	0.08
Total			
Control	20.2 ± 3.1		
Intervention	20.1 ± 2.6	0.83	0.04

electronic materials (class recordings and slides) especially helpful to their learning. This result fits the traditional expectation that the instructor will provide study materials specifically focused on preparing for summative assessments. Since the class format was aligned with these expectations, students in the Control section also reported significantly higher satisfaction levels with the teaching style.

When rating class activities that help learning, students in the blended learning section (Intervention) responded more positively to the textbook readings, weekly quizzes, and summative assessments. These results reflect a shift in thinking from a grade-based to a learning-focused emphasis. Daily in-class activities often incorporated reflection on the learning process and how to best use available resources to support learning. Such activities may have contributed to the open-ended responses from many students reflecting a degree of personal growth associated with their learning in the course. Pedagogically, this approach supports students in the more affective qualities that have been termed "learning how to learn" [11]. Perhaps as a result of these activities, students became more cognizant of the role of testing in the learning and feedback cycle. In the open-ended questions, students mentioned an appreciation for using quarterly exam results both to assess their learning and to troubleshoot their study habits, focusing on improving their results as they moved through the course.

Students' perceptions of their own learning relative to level of effort was decreased in the blended learning class section compared to the traditional section, even though the students in the blended learning section achieved similar learning outcomes as measured by exams and a pre-/post-class assessment. In fact, a substantial number of students in both class sections mentioned that they believed their achievement in the course (i.e., exam grades) did not reflect their learning. These results indicate a misalignment between how much students believe they have learned and the summative assessment results.

One goal of the blended learning environment is to improve the quality of interactions among students and instructors to promote mentoring and coaching relationships. Interestingly, students in the blended learning section were significantly less positive than those in the traditional section about how the structure of the course encouraged interactions with instructors. This result occurred despite a course design that included formative assessment activities that were expected to increase interactions among students and instructors. The formative assessments did increase learning satisfaction more in the blended learning section than in the traditional section. However, it seems likely that the availability of opportunities to practice applying knowledge to problem-solving using online resources actually reduced the number and/or quality of faculty-student interactions. While such tradeoffs may be desirable in asynchronous or online learning formats, they are usually viewed negatively in active classroom formats.

Increasingly, STEM higher education studies are supporting the shift from traditional lectures to course designs that increase students' engagement with their own learning [2], [3]. Students may prefer the "traditional lecture", represented by the "sage on the stage" model in which an instructor as expert uses the lecture only as a means to deliver content, because it is a more familiar or more comfortable format [3]. However, questions remain about how student satisfaction and faculty-student interactions are related to summative outcomes. Students in the Control section of the physiology course in this study, who were more satisfied with traditional aspects of the course design, tended towards higher scores on test questions measuring retention and recall, whereas students in the Intervention section tended towards higher scores on test questions associated with comprehension of physiological mechanisms [7]. Even though students in the two sections achieved similar scores overall on summative assessments, their increased performance in specific areas may reflect their increased satisfaction with course activities designed to support those areas. This hypothesis remains to be tested directly.

One could argue that the evidence against effectiveness of lectures is strong enough that researchers should no longer compare active learning approaches to those lectures; instead, the focus should shift to identifying the most effective active learning approaches [12]. This study suggests that differences in outcomes may be less pronounced if student satisfaction and faculty-student interactions are linked to learning. Aspects of the traditional format valued by students included faculty-student interactions and methods of delivering content through lectures and class recordings. In the blended classroom format, students appreciated the frequency of opportunities to practice their learning. Whether the blended learning environment really led to a shift in thinking associated with critical thinking and lifelong learning remains to be examined.

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