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INSTRUCTIONAL DESIGN AND ASSESSMENT

Transforming a Large-Class Lecture Course to a Smaller-Group Interactive Course

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Objective. To transition a large pharmacokinetics course that was delivered using a traditional lecture format into a smaller-group course with a discussion format.

Design. An e-book and Web-based multimedia learning modules were utilized to facilitate students' independent learning which allowed the number of classes they were required to attend to be reduced from 3 to 1 per week. Students were assigned randomly to 1 of 3 weekly class sessions. The majority of lecture time was replaced with active-learning activities including discussion, problem solving, and case studies to encourage higher-order learning.

Assessment. Changes in course delivery were assessed over a 4-year period by comparing students' grades and satisfaction ratings on course evaluations. Although student satisfaction with the course did not improve significantly, students preferred the smaller-group setting to a large lecture-based class. The resources and activities designed to shift responsibility for learning to the students did not affect examination grades even though a larger portion of examination questions focused on higher orders of learning (eg, application) in the smaller-group format.

Conclusions. Transitioning to a smaller-group discussion format is possible in a pharmacokinetics course by increasing student accountability for acquiring factual content outside of the classroom. Students favored the smaller-class format over a large lecture-based class.

Keywords: educational technology, learning, active learning, pharmacokinetics

INTRODUCTION

College class size influences course and instructor evaluations,[1] student motivation and accountability,[2] grades,[3,4] and types of learning that can be achieved.[5] These elements are interdependent to some extent, eg, motivation may be increased if students are engaged in problem solving, which typically is pursued only in relatively small classes, as opposed to simply receiving information, which is the hallmark of large, lecture-based courses.[6] Consequently, higher-order learning is more easily achieved in smaller class settings than in larger ones.[5] For example, in courses that focus on writing, a class size of fewer than 20 students is recommended, and probably no more than 15 is ideal, because of the individualized attention needed to develop that skill set.

Despite the recognized advantages associated with small class sizes, higher education often is forced into having large classes because of economies of scale. To address pharmacy manpower shortages, for example, many pharmacy programs have increased class sizes, in many cases by pursuing distance education strategies. While the need for more pharmacists has resulted in increased class sizes, simultaneous demands from the profession and accrediting bodies for well-prepared graduates have led to increased interest in incorporating active-learning strategies. Such strategies encourage deep learning (ie, critical analysis of new ideas and the linking of new ideas to concepts and principles that the learner already knows, which lead to understanding and long-term retention of concepts so that they can be used for problem solving in unfamiliar contexts) and develop students' communication, problem-solving, and thinking (creative, critical, practical) skills. Thus, these 2 opposing forces – economy-driven increases in class size and pedagogically desirable decreases in class size – result in complex and sometimes contentious course design issues.

Student accountability is a concern when considering strategies for restructuring course delivery to support active learning while continuing to serve large numbers of students.[2] In some respects, students may be viewed as consumers in the educational enterprise in that they are paying to be taught, and therefore may not be amenable to taking a sufficiently active role in their learning. Student

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accountability, however, is crucial to deep learning because it contributes to self-regulation, perception of control, and motivation.[7-9] The challenge has been to increase student accountability for learning (primarily in the acquisition of foundational content) so that class time can be redirected from one-way transmission of factual information to interactive activities that help achieve the desired higher levels of learning.[10]

This manuscript describes the initial results of transitioning a large, lecture-based course that focused predominately on lower levels of learning into a smaller group course based on application, discussion, and problem solving to achieve higher levels of learning. Specifically, a foundational pharmacokinetics course in a professional pharmacy program that included a small satellite campus was redesigned to increase student accountability through more independent learning and increase the time spent on facilitating and assessing learning beyond that of knowledge and comprehension. The impact of this change on student performance and attitudes was assessed.

DESIGN

Course Organization and Delivery

Pharmacokinetics instruction in the doctor of pharmacy (PharmD) program at the School of Pharmacy at The University of North Carolina at Chapel Hill consists of a 2-semester sequence beginning in the fall of the second year. Pharmacy 413 is a 3-credit course that is offered in the fall semester and serves as the foundational pharmacokinetics course of the curriculum. Students from 2 sites, Chapel Hill and Elizabeth City State University (ECSU), participate in the course. Admission to the program at either campus is through a centralized admissions process.

In 2006, 144 students were enrolled in the course (132 at Chapel Hill and 12 at ECSU). The class met 3 times each week for 50 minutes, and students were required to attend all class sessions. Class time was devoted predominately to traditional lectures with active-learning activities held periodically. An e-book, written by one of the instructors, was provided to students as supplemental course information.

In 2007, the 148 students enrolled in the course (138 at Chapel Hill and 10 at ECSU) were divided into 3 groups. Chapel Hill students were randomly assigned to 1 of 3 class sessions, and all of the ECSU students were assigned to 1 of the 3 sections. For the majority (approximately 80%) of the semester, each group met once a week for 50 minutes, rather than 3 times a week as in 2006. Class time was used for discussion, problem-solving, case studies, or other types of active learning. Students were asked to prepare for class either by reading the e-book or completing online, interactive, Flash-based modular material. Approximately 30% of the course content was available in online format in 2007; the remaining 70% was still in development. For the 20% of time in which smaller groups were not used, all students attended class as a large group, but the discussion and problem-solving format used for the smaller groups was still used.

In 2008, 144 students were enrolled in the course (137 at Chapel Hill and 7 at ECSU). For 88% of the course, class met once a week for 75 minutes, with approximately 50 students randomly assigned to each session as per the previous year's format; this was repeated 3 times a week for each section of students; the ECSU students again were all assigned to the same section along with approximately 40 Chapel Hill students. For the remaining 12% of course time, the class met as a large group to discuss topics instead of in their smaller group sections. In 2009, class size was 149, with 137 students at Chapel Hill and 12 at ECSU. As in 2007, class time for the course in 2008 and 2009 was used for discussion, problem solving, case studies, and other types of active learning activities. Students were asked to prepare for class either through reading the e-book or completing the online, interactive material. Approximately 75% of the course content was available in the online format in 2008 and 100% in 2009.

Preparatory Material

Students were asked to prepare prior to coming to class using available, instructor-designed resources, the e-book, or interactive, online material. The modular, multimedia material consisted of 9 separate modules (18.5 hours of material).[12] Each module and individual unit within the module began with learning objectives and ended with practice exercises that related to those objectives. Each section was composed of 3 to 8 scenes that were fully narrated and animated in Flash, version 8 (Macromedia, Adobe , San Jose, CA). An answer-until-correct quiz that assessed each of the overall learning objectives was included at the end of each module; all assessments (practice problems and quizzes) within the Web-based material were considered formative self-assessments; quizzes were replicated on Blackboard (Blackboard, Inc, Washington DC) for students who primarily used the e-book. Problem sets and old examinations were made available to students but were used for self-assessment purposes only.

Immediate-Feedback Assessment Technique

In all 4 years, student learning was assessed with multiple-choice questions presented in an answer-until-correct format using immediate feedback forms.[11] Questions were constructed to assess the student's level of learning according to Bloom's Taxonomy, consistent with

the stated learning objectives for the course. The levels of learning were separated into 3 categories to facilitate classification of questions and were consistent with curriculum mapping efforts: level 1 = knowledge and comprehension; level 2 = application and analysis; and level 3 = synthesis and evaluation. Questions were arranged sequentially by level beginning with level 1 material. Examination questions each had 5 answer choices; in cases when no reasonable fifth choice existed, 4 choices were used. Scores were determined by the number of attempts required to answer the question correctly: the first attempt (as defined by 1 block scratched on the immediate feedback form) earned full credit (5 points); the second attempt (2 blocks scratched) earned 3 points, and the third attempt (3 blocks scratched) earned 1 point. Students were encouraged to scratch as many blocks as necessary to discover the correct answer, although questions requiring more than 3 attempts earned no points. Examinations accounted for 87% of the final grade, with the remainder determined by 5 reflective writing assignments.[12] The University's institutional review board classified this study as exempt from review.

EVALUATION AND ASSESSMENT

Admissions data over the study period was constant in terms of grade point average (3.5 / 4.0), Pharmacy College Admissions Test (PCAT) scores (top 85%), and number of students with previous degrees (~65%). A retrospective study comparing examination scores from 2007, 2008 and 2009, when the smaller-group format was used, with scores from 2006 when the large-group format was used was conducted using two-way ANOVA (format and level of learning) with a Tukey's post-hoc comparison strategy. The criterion for statistical significance was set at $p < 0.05$. No class format-by-level differences (Table 1) or class format-by-level-by-campus differences (data not shown) were found despite the increase in the percentage of questions asked at the level of application or analysis (ie, level 2). However, students' mean score on questions evaluating the highest level of learning (level 3) were significantly lower than scores on questions evaluating the lower 2 levels of learning (Table 1).

Course Survey Data

Attitudinal surveys were used to collect information on student perceptions of the course and the learning experience. Students' responses were compared between campuses using a *t* test after collapsing the data from the years in which the smaller-group format was used. When possible, formal course evaluations were used to compare formats; however, course evaluation questions were changed during the 4-year period, limiting comparisons.

In general, attitudinal surveys were consistent with the students' reflective writing statements that were completed during the course. Sixty-three percent of students preferred the smaller-group format compared to 20% who preferred a traditional, large-class format, with the remaining students indicating no preference. Slightly more students preferred that class time have a more transparent structure (eg, formal case presentations or problems) rather than a more translucent structure (eg, Socratic discussion), 46% versus 41%, respectively. Sixty percent of students favored the e-book as a resource for class preparation compared to 21% who favored the Web-based material; the remaining 20% of students indicated no preference. The most frequently cited reasons students gave for preferring the e-book to the Web modules were that the e-book was easier to self-pace, quicker to go through, and allowed student annotation. The most commonly-reported advantage of the Web-based material was that it appealed to more visual learners and complemented the written material. Approximately 70% of students used both resources, while 28% only used the e-book. Approximately 65% of students who used both resources read the book first and then use the corresponding Web-based module. The students also felt that they had flexibility in their learning (Table 2).

Overall, students felt the course structure supported their learning, and did not indicate that they missed instructor contact time (1 vs. 3 weekly class meetings)

Table 1. Distribution of Examination Scores Based on Level of Learning

	Traditional Lecture Format (2006) (N = 107)		Small-Group Discussion Format (2007-2009) (N = 265)	
Level of Learning	Items, No. (%)	Scores, Mean (SD)[a]	Items No. (%)	Score, Mean (SD)[a]
Level 1	32 (30)	4.6 (0.4)	38 (14)	4.7 (0.3)
Level 2	61 (57)	4.5 (0.6)	201 (76)	4.4 (0.6)
Level 3	14 (13)	3.8 (0.7)[b,c]	26 (10)	3.6 (0.9)[b,c]

[a] Score out of 5 points.
[b] $p < 0.005$ compared to Level 1 two-way ANOVA.
[c] $p < 0.005$ compared to Level 2 two-way ANOVA.

Table 2. Results From Attitudinal Surveys Collected From Students Enrolled in a Pharmacokinetics Course Taught in a Smaller-Group Discussion Format, 2007-2009

Item	All Students		Chapel Hill Campus		ECSU	
	Responses, No.	Mean (SD)	Responses, No.	Mean (SD)	Responses, No.	Mean (SD)
In the current format, in order to be successful (ie, really understand the material), coming to class in essential	416	3.1 (1.2)	390	3.1 (1.2)	29	2.9 (1.2)
I feel I missed out on instructor contact because of the format of the class	415	2.2 (1.2)	388	2.2 (1.2)	28	2.0 (1.3)
I feel I missed out on learning because of the format of the class	414	2.2 (1.2)	388	2.2 (1.2)	29	2.5 (1.5)
I feel I gained on learning because of the format of the class	407	3.4 (1.1)	380	3.4 (1.1)	29	3.3 (1.2)
I feel the contact time with the instructor was of better-quality in the small group format than the traditional large group format? [a]	280	3.9 (1.1)	263	3.9 (1.2)	18	4.5 (0.8)
I feel like I have a choice over how I am going to learn in this course [a]	284	4.4 (0.8)	266	4.4 (0.8)	19	4.3 (0.7)
This course has sharpened my analytical/problem solving skills [a]	281	4.2 (0.8)	263	4.1 (0.8)	19	4.2 (1.0)
I feel more confident about tackling unfamiliar problems [a]	282	3.9 (0.8)	264	3.9 (0.9)	19	4.2 (0.6)
This course has helped me develop the ability to plan my own work [a]	283	4.1 (0.9)	265	4.1 (0.9)	19	4.2 (1.0)
Comparing class formats, how would you rank the amount of time you spend studying/preparing for this class format compared to if this class was a traditional large group lecture format? (5 = more time; 1 = less time)	423	3.3 (1.0)	394	3.3 (1.0)	29	3.4 (1.1)
On a scale of 1 (not very) through 10 (very), how comfortable are you learning on your own?	421	7.5 (1.9)	392	7.5 (1.8)	29	7.3 (2.8)
On a scale of 1 through 10, how much did the exam format (immediate feedback), increase your anxiety level (1 = no impact;10 = large impact)	417	4.6 (2.8)	390	4.6 (2.8)	29	4.2 (3.1)
Approximately how much time per week do you spend preparing for class? (in hours)	412	3.2 (1.9)	390	3.1 (1.8)	28	3.9 (3.1)
How much time per week (in hours) should a student spend preparing for an individual class?	385	3.8 (1.9)	236	3.7 (1.9)	27	4.5 (2.6)

Abbreviations: Chapel Hill = University of North Carolina at Chapel Hill; ECSU = Elizabeth City State University.
Responses based on a scale of 1 to 5: 5 = strongly agree, 3 = neutral, 1 = strongly disagree.
[a] Only asked in 2008 and 2009.

(Table 2). In fact, the students felt the quality of instructor-student time was improved by using the smaller-group format with less-frequent meetings. Approximately 43% of students felt they did not spend any more or less time preparing for this class compared to other classes. Forty-one percent felt they spent more time preparing for this particular course. Students estimated spending an average of 3.2 hours (range 0.5 to 15 hours) per week preparing for the class. However, they felt they should have spent 3.8 hours a week (range 0.5 to 10 hours). Students also felt that the course helped them manage their time and acquire problem-solving skills. Students were neutral on the proposition that attending in-class discussion was necessary for success in the course. The immediate feedback examination format appears to contribute modestly to examination-related anxiety (Table 2). Finally, for all years except 2009, students' overall rating of the course on the end of the semester evaluation was in the top 10th percentile of all courses offered in the fall semester; in 2009 the course was in the top 25th percentile.

DISCUSSION

The 21st century has been referred to as the Information Age. Because the information base for many disciplines has become too extensive to master and because information is increasingly easy to obtain, it is ever more important for educators to focus on developing students' skills beyond simple content acquisition.[13] Higher education must focus more on how to analyze, evaluate, and communicate information, as well as how to use it to solve problems; think critically, practically and creatively; and work in group settings. Helping students to develop these desirable skills is difficult in the traditional large class setting where lecture is the predominant teaching format. One way to accomplish these goals, however, is by reducing class size (often not practical for economic, social, or political reasons) or by using group work or other course-restructuring strategies to make large cohorts of students function as smaller groups.[14] We have taken a course with a large (~150 students) class size and a lecture-based format and transitioned it into a course with smaller (~50 students) class sizes and a discussion-based format by increasing student responsibility for learning basic content on their own.

Students were capable of acquiring basic content outside of the classroom, as indicated by examination scores on questions focused on content mastery, and they felt comfortable doing so. This was facilitated by instructor-prepared materials and self-assessment opportunities (eg, problem sets, quizzes), as well as class time to explore questions. Students tend to prefer smaller class sizes as indicated by higher student evaluation scores.[15] Also, when the number of students at a distance site is closer to the number of students at the hosting site, student opinions of the course are more favorable.[16] Because we grouped all the distant-site students into 1 section, the ratio of host students to distant students was reduced from approximately 14:1 to 4:1 in that class. In addition to preferring the small class format, students preferred discussion sessions that were well structured as opposed to unstructured. This finding is consistent with the literature on cooperative learning, which indicates that structured activities are preferred over less-structured activities.[9]

An underlying tenet in the transition in this course was that deep learning of material is facilitated through discussion and problem-solving activities. Examination scores reflected this theory to some extent, as an increase in the proportion of "difficult" questions (ie, those focusing on higher orders of learning such as application and analysis) did not result in decreased examination scores. Although students felt that attending class to participate in discussion and problem-solving activities was not necessary for success in the course, the benefit associated with attendance may appear in courses later in the curriculum, during their experiential education in the final year of the curriculum or even as they enter practice (the ultimate goal of the educational process) because class discussions related to topics they will need to consider in the future. Long-term surveys designed to assess the impact of this course on skill set retention would be needed to address this issue.

One of the secondary objectives in transitioning to a smaller-group format was to investigate how best to facilitate independent student learning. The 2 major sources for providing basic content and factual information to the students were an electronic book and modular multimedia material. Each source was viewed as having advantages and disadvantages by the course faculty members and students. For the faculty members, developing the multimedia material consumed more time than developing the electronic book, required substantial financial investment, and could be pursued only through a strong partnership with the university's information technology services group. An advantage of the multimedia material from a faculty perspective was that it incorporated click-stream tracking, which could be used to help assess problem areas in student learning (eg, where students spent the most time), and to ensure student accountability. From the students' perspective, the e-book and Web-based material could be viewed and used from any location. However, most students printed the e-book and some noted that the Web-based material, which could only be viewed online, was a disadvantage as they did not want to be tethered to their computer. The students indicated that the e-book was more efficient. This is consistent with the differences between reading and speaking; the average reading speed tends to be faster (200-400 words per minute)[17] than the pace of narration within the Web-based material (~100 words per minute) thus students can go through more material in a shorter period of time via reading than viewing the module. Pharmacokinetics is, by nature, a dynamic subject that does not lend itself to presentation in a static, unchangeable format such as a traditional textbook. Consequently, an advantage of the Web-based material was the ability to demonstrate temporal relationships (eg, changes in concentration over time) through animation. Although Millennial students tend to read less,[18] and therefore may be more amenable to content acquisition from narrated, animated material, this contention may not be applicable to the academic setting because these data focus on leisure reading. Students indeed may tend to read less for leisure, preferring other forms of media, but there do not appear to be any significant changes in reading within the context of school work.[19] In addition, to some

extent, reading material on the Internet may take the place of traditional leisure reading, although no comprehensive analysis has been performed of which we are aware. While the contention that contemporary students require visual rather than textual presentation of material may be overstated, having a mixture of formats for presenting content to students is always advantageous as it covers multiple learning preferences.

The major limitation to this report is there was no available data to compare the new course format to the traditional lecture format except for the overall course ratings on student evaluations. As noted, the formal year-end course evaluation questions changed during the time of this study, making comparisons difficult. In addition, there were no survey data for the traditional course. Surveys were conducted on the new course format only to provide feedback to the course coordinators. However, in answering many of the survey questions, students could reference their experience with the traditional lecture format used in other courses for comparison.

CONCLUSIONS

This study demonstrated that students could acquire course content outside of class successfully and be held accountable for that acquisition, and that by doing so, the frequency of class meetings could be reduced, thereby allowing a large group of students to meet in smaller cohorts. No decrease in content breadth or students' depth of learning or skills proficiency was observed, even with material as challenging as foundational pharmacokinetics. Moreover, students could complete examinations that assessed higher orders of learning without a decrease in examination performance when the smaller-group discussion approach was used. This study also indicates that in an era when blended-learning strategies are increasingly popular, outside-of-class learning does not have to be technology based, but can be from any type of student-friendly material. Further work is required to refine content delivery and class-discussion strategies, and to assess the degree to which this approach may be amenable to other disciplines or courses.

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19. National Center for Education Statistics. Table 118: Average reading scale scores and percentage distribution of 9-, 13-, and 17-year-olds, by amount of reading for school, frequency of reading for fun, and time spent doing homework and watching TV/video: selected years, 1984 through 2008. www.nces.ed.gov Accessed October 20, 2010.