INSTRUCTIONAL DESIGN AND ASSESSMENT

A Blended Learning Approach to Teaching Basic Pharmacokinetics and the Significance of Face-to-Face Interaction

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Objective. To assess pharmacy students' attitudes towards a blended-learning pharmacokinetics course.

Design. Narrated visual presentations and animations that illustrated kinetic processes and guided students through the use of software programs used for calculations were created. Other learning techniques used included online self-assessment quizzes, practice problem sets, and weekly face-to-face problem-solving tutorials.

Assessment. A precourse questionnaire to assess students' level of enthusiasm towards the blended-learning course and to solicit any concerns they had was administered at the beginning of the course. A postcourse questionnaire that included the same 4 Likert-scale items from the precourse questionnaire and follow-up open-ended questions was administered. Individual changes in level of enthusiasm were compared for individuals who completed both the precourse and postcourse questionnaire. Students' concerns about the blended method of learning had decreased postcourse while their enthusiasm for the benefits of blended learning had increased.

Conclusion. Students' initial concerns about the blended learning experience were focused on their ability to communicate with the instructor about the online components, but shifted to their own time management skills at the end of the course. Face-to-face interactions with each other and with the instructor were more highly rated than online interactions in this course.

Keywords: pharmacokinetics, blended learning, student questionnaire, interaction, social presence

INTRODUCTION

The integration of face-to-face and online instruction and interaction to design "blended" courses is a strategy that has found solid acceptance in higher education and corporate training programs over the last decade.¹ At the University of Waterloo a blended course is one where well-designed online activities are integrated with face-to-face interaction. Higher satisfaction levels among faculty members and students, better learning outcomes for students, and increased access and flexibility in the time, pace, and place of learning are all cited as strengths in blended-learning courses as compared to traditional lecture-based courses.²⁻⁶

Opportunities for collaborative learning and for student-faculty interactions are key to the success to blended courses and increase student satisfaction.^{7,8} Garrison and Kanuka argue that blended learning has "transformative potential" and can support the formation of communities of

inquiry.⁹ Communities of inquiry in blended courses support students' need for cognitive and social presence and rely on a strong teaching presence by the instructor. The inclusion of thoughtfully designed course components that encourage active participation in the learning process are critical to the success of blended courses.¹⁰⁻¹²

Blended course design models are effective in teaching pharmacy students in the areas of microbiology, adult acute care medicine, pharmaceutical biotechnology, and cardiovascular pharmacotherapy.¹³⁻¹⁶ In general, these courses were well received by students and instructors reported that the blended, or hybrid, approach was an effective way for students to achieve course objectives. However, our approach of quantitative and qualitative analysis of students' feedback about their concerns with this nontraditional approach to learning through pre- and post-course questionnaires has not been attempted in this discipline before. The specific topic of blended learning in pharmacokinetics was the focus of this study.

Pharmacokinetics aims to describe drug absorption, distribution, metabolism, and excretion mathematically as a means of predicting drug behavior in specific patient

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subpopulations. A pharmacokinetics fundamentals course is offered in most pharmacy curriculums; however, it is generally not well received by students due to its basis in mathematics and the difficulty experienced in linking basic concepts with clinical relevance.¹⁷

The objectives of this work were: to develop a basic pharmacokinetics course that relied on the integration of online modules for the delivery of concepts and practical computational skills with face-to-face problem-solving tutorials; and to assess the attitudes of students to this new method of learning both prior to and following course completion.

DESIGN

At the University of Waterloo, Ontario, Canada, enrollment to the new bachelor's degree in pharmacy program requires at least 2 previous years of relevant undergraduate experience; although the majority of students entering the vanguard class had at least a relevant bachelor's degree. Integrated Patient Focused Care 1 (IPFC1) was offered for the first time to the vanguard class in their second year of the program in winter 2009. This course is an intensive 6-week (18 hours/week) segment of a core course and challenges students to understand fundamental principles of pharmacokinetics, immunology, clinical biochemistry, infectious disease, critical appraisal, and patient-focused care. The course is designed such that the largest section, pharmacokinetics (7 hours/week), is in a blended learning format where students engage independently in weekly online modules and activities in lieu of class time (6 hours/week) and meet once a week for face-to-face problem-solving tutorials with the instructor (1 hour/week). This section focuses on basic concepts of absorption, distribution, elimination, one- and multi-compartmental kinetics, constant-rate and multiple dose administrations and dosing regimen design. The remaining section of the course, Foundational Material (11 hours/week), provided basic information in a traditional lecture format on the topics outlined above to ensure students would be able to grasp the more integrated topics discussed in the remaining 7 IPFC courses. The pharmacokinetics course section had the following learning objectives:

- (1) Illustrate and explain the role of formulation, drug physico-chemistry, and physiology on the absorption profile and bioavailability of drug administered by nonintravenous routes.
- (2) Explain how the factors driving distribution volume affect drug pharmacokinetics.
- (3) Describe the clearance concept with respect to plasma and intrinsic clearance, as well as metabolite and urinary kinetics.
- (4) Derive relevant pharmacokinetic parameters by mathematically describing a pharmacoki-

netic profile following single intravenous and non-intravenous administration.

- (5) Given relevant pharmacokinetic parameters, apply pharmacokinetic equations to calculate drug concentrations in biological fluids following bolus, infusion, and single and multiple administrations.

Due to the foundational nature of the subject, the objectives primarily cover the knowledge and comprehension categories of Bloom's cognitive domain, with a minority of content falling under the application category (eg, apply pharmacokinetic principles to derive a reasonable dosing regimen).¹⁸

Rationale for Blended Learning Approach

Web-based modules for teaching pharmacokinetics have been used by others.^{19,20} Mehvar demonstrated that, in addition to in-class time, Web-based modules of basic concepts and a Web-based assignment/feedback system were well accepted by students and improved learning outcomes.¹⁹ Ninety-five percent of students responded that the use of computers in this pharmacokinetics course is worthwhile and should be continued.¹⁹ A randomized parallel group study was conducted at the School of Pharmacy at The University of North Carolina at Chapel Hill that examined the effectiveness of a short 1.5-hour online module to replace a 4-hour lecture series on hepatic clearance traditionally given in class as a source of foundational material.²⁰ While test scores were equivalent between the groups, a higher percentage of students (24%) in the group that viewed the online module selected it as their preferred presentation method vs. only 3% in the group that received the traditional lecture.²⁰

Based on this and other research suggesting improved test scores with use of a module,²¹ we decided to deliver all basic pharmacokinetic content online.

Educational Environment

Online modules were created using the screen capture tool Camtasia (version 6.0, TechSmith, Okemos, Michigan). The modules incorporated narrated PowerPoint presentations, Adobe Flash videos, tutorials on the use of Excel, and external Web sites. The modules were delivered through the institution's course management system, UW-ACE (University of Waterloo Angel Course Environment which is provided by Angel Learning Systems Inc.). Self-assessment quizzes were available to students at the end of learning modules and problem sets were assigned that complemented the weekly learning module. Two instructor-led, face-to-face, 1-hour tutorial sessions were given each week, with half the class attending one session and the rest of the class attending the other. The purposes for the tutorial were (1) to answer the questions

in the problem sets collectively and answer students' questions; and (2) to highlight or explain particularly difficult concepts identified by the students. Four problem-based assignments and 2 examinations were administered to assess student understanding of the course concepts. An evening review class that allowed students to ask questions or work through problems from the textbooks with the instructor was provided prior to each examination. Two texts were required for the course, one of which was available to students online.^{22,23} Discussion forums and e-mail were used as communication tools within the course management system and the instructor frequently met with students in her office to provide help to individuals and small groups. Students were encouraged to work with each other on the problem sets that accompanied the weekly modules, but were expected to complete the graded assignments individually.

Content

The pharmacokinetics section of the IPFC1 course was divided into 6 weeks:

Week 1: introduction to absorption, distribution, metabolism, and elimination; math review; general factors affecting drug distribution and elimination.

Week 2: compartmental kinetics (intravenous); one-compartment kinetics (extravascular)

Week 3: absorption

Week 4: distribution

Week 5: metabolism and excretion

Week 6: Intravenous constant-rate infusion; multiple dosing

Week 2, for example, contained 6 videos; (1) "Intravenous Dose," (2) "Examples With One and Two Compartments," (3) "Extravascular Dose," (4) "Assessment of Area Under the Curve," (5) "Bioavailability and Bioequivalence" and (6) "Summary of Concepts." Videos were put online the Friday prior to the beginning of week 2. In addition, a problem set was provided for students to attempt prior to the tutorial session on Friday where the problem set was completed and discussed with the instructor. An assignment on the content of week 2 was given to students on the Monday of week 2 and was due on the Tuesday of the following week. Other activities in week 2 included a YouTube viewing of a University of Toronto professor's lyrical explanation of bioequivalence,²⁴ Excel macro downloads and explanation of their use for the performance of simple pharmacokinetic parameter calculations, as well as readings and practice problems from the texts.

On the first day of classes in winter 2009, the instructor met with students to explain the format of IPFC1. Students were told that upon their first entrance into the course Web site, they would be asked to complete an

online questionnaire prior to commencing the 6-week segment of pharmacokinetics and again after they had completed it. All questionnaires were approved by the Human Research Ethics Board of the University of Waterloo. Students were asked to create their own unique, confidential username that would allow their responses to remain anonymous and allow for comparison between responses on the pre- and postcourse questionnaire. The introduction to both questionnaires included a definition of blended learning that students could refer to throughout the questionnaires.

The precourse questionnaire asked questions concerning the student's level of enthusiasm towards certain aspects of the blended course including: interacting with online course modules, online interaction with the instructor, face-to-face interaction with the instructor in problem-solving sessions, and learning in a blended course environment (Appendix 1). Their level of enthusiasm was assessed using a 5-point Likert scale on which 1 = very enthusiastic and 5 = not enthusiastic. The precourse questionnaire also included an open-ended question that asked students to express any concerns they had about taking a course in a blended format. Students were also asked to indicate whether they had taken a blended or fully online course before this course.

The postcourse questionnaire was completed prior to the final examination and included the same 4 Likert questions from the precourse questionnaire, where students were asked to indicate their level of enthusiasm towards certain aspects of the blended course as well as a follow-up open-ended question about their precourse concerns. Additional open-ended questions were asked, inviting student feedback on how course activities and teaching methods helped them to remember key concepts, their perceptions of the most and least effective aspects of the blended course, suggestions for improving the course, and advice to other students taking a blended course for the first time. Likert-scale questions about the helpfulness of specific course elements (eg, the face-to-face tutorials), assessments (eg, weekly problem sets), and course resources (eg, equation information sheets) to their learning as well as questions about the helpfulness of interactions with their peers and instructor online and face-to-face also were included in the postcourse questionnaire. Questions about their satisfaction with the technology and learning gains on specific course objectives were also included to help the instructor gauge the success of the first offering of this course. Thirty-one Likert-scale questions and 1 yes/no question was asked (Appendix 1). Many questions were adapted from the Student Assessment of their Learning Gains (SALG) questionnaire, which allows instructors to gather learning-focused feedback from students and from

the Garrison's blended course questionnaire.²⁵ Our questionnaire was reviewed by a University of Waterloo education research consultant prior to its administration. Since this article focuses on the shift in attitudes about blended learning between the beginning and end of the course and the aspects of the blended-learning experience that students found helpful and challenging, not all the response data gathered in the postcourse questionnaire will be discussed.

Statistical Analysis

Descriptive statistics, frequencies of the response options, and response modes were used to analyze the responses to each of the Likert-scale questions and to provide a picture of attitudes (at both points in time) in the precourse and postcourse questionnaires. A content analysis of the qualitative data was undertaken by 3 different people. A coding scheme was created independently by each person for each of the open-ended questions. In order to achieve interrater reliability, only interpretations of content identified by at least 2 of the 3 people were included in the analysis.

Since there were not enough paired observations to confidently test whether the differences in the precourse and postcourse questionnaire data were normally distributed and the distributions of the responses appeared to be skewed, a Wilcoxon signed rank test was used to test for significant differences ($p < 0.05$) between the precourse and postcourse questionnaire responses for the pairs where there was a match of identifiers for both questionnaires. This test takes into account the pairing of responses of students and compares the positive and negative differences between measurements, and takes into account the size of the difference between them. The test treats responses as ordinal (or ranked) data, which is appropriate given the subjectivity of responses to Likert-scale questions.²⁶

EVALUATION AND ASSESSMENT

Seventy-five percent of students (67/89) completed the precourse questionnaire; the response rate dropped to 55% (49/89) for the postcourse questionnaire. Students were not given any course credit or other incentive to encourage them to participate. Identifiers used by some students varied between the 2 questionnaires, which precluded comparison between some precourse and postcourse responses. Due to attrition and students changing their identifier between the 2 questionnaires, not all responses could be matched. Identifiers that were identical (or not identical but had a high likelihood of belonging to the same student) were included in the final analysis, allowing for 28 paired comparisons to be made. Wilcoxon signed ranks tests were used to test for differences in the matched pairs of data.

Comparison of Pre- and Postcourse Responses Between Matched Pairs

Learning in a blended course environment. The number of students who were "very enthusiastic" about learning in a blended course environment increased 25% from precourse to postcourse questionnaire, while the number who were "neutral" decreased by 17.8%. The modal category for both time 1 (precourse) and time 2 (postcourse) was "enthusiastic" (Figure 1). The data indicate that students were more enthusiastic towards learning in a blended format at the end of the course than at the beginning of the course ($p = 0.037$).

Interacting with course learning modules online. The number of students who were in the "very enthusiastic" category increased 21.2% while the largest decrease (37.4%) was in the "neutral" category. The modal category was "enthusiastic" for both time 1 and time 2 (Figure 2). There was a positive relationship between time and the students' level of enthusiasm towards interaction with online course modules for the 28 matched pairs of data ($p = 0.049$).

Interaction with your instructor online through e-mail and discussion forums. The largest categorical increase was in the "very enthusiastic" category (7.2%), while the largest decrease (7.1%) was in the "not enthusiastic" category. The modal category was "neutral" for both time 1 and time 2 (Figure 3). Although there was an overall positive shift in the responses, it was not significant.

Interaction with your instructor in face-to-face problem-solving sessions. The largest categorical increase was seen in the "very enthusiastic" category with an increase of 32.1% while the largest decrease equal to 28.6% was found in the "enthusiastic" category. The modal category for Time 1 was "enthusiastic" while the modal category for time 2 was "very enthusiastic." No students indicated any level of enthusiasm less than "neutral" (Figure 4). Students were more enthusiastic about face-to-face

Figure 1. Paired responses from the precourse (time 1) and postcourse (time 2) questionnaire regarding the level of enthusiasm for learning in a blended course environment, $n=28$.

Figure 2. Paired responses from the precourse (time 1) and postcourse (time 2) questionnaire regarding students' level of enthusiasm for interacting with course learning modules online, n=28.

interaction with the professor at the end of the course than at the beginning the course ($p = 0.04$).

Student concerns about taking a course in a blended format. Less than one third of the class responded to the question in the precourse questionnaire about taking a course in a blended format. The major concern (7/26 comments) students expressed was the limited face-to-face time with the instructor (Table 1). Many who made this comment were specifically worried about being unable to ask questions and get immediate answers about course concepts during the online lectures. Some students were concerned about their ability to understand complex material online (3/26), without the opportunity to interact with the instructor and fellow classmates. Time management/personal organization (3/26) was another point of concern, as was students' ability to follow a course schedule without having the structure of attending weekly classes. The postcourse questionnaire asked students to identify whether their precourse concerns were still present. Twenty-three students' responded to this question but several students indicated

Figure 3. Paired responses from the precourse (time 1) and postcourse (time 2) questionnaire regarding the level of enthusiasm for interacting with the instructor online through e-mail and discussion forums, n=28.

Figure 4. Paired responses from the precourse (time 1) and postcourse (time 2) questionnaire regarding the level of enthusiasm for interacting with the instructor in face-to-face problem solving sessions, n=28.

positive aspects of the blended course rather than indicating if their prior concerns were still present. Only 3 students expressed concerns about the lack of face-to-face time with the instructor and 4 expressed concerns about time management/personal organization.

Responses to Postcourse Likert Questions

The most relevant questions addressed the helpfulness of interacting with course materials online, participating in face-to-face problem solving tutorials and the students' interactions with their instructor and peers. Seventy-three percent of students indicated that interacting with online course materials provided either "much help" or "great help" to their learning experience. The majority of respondents, 54%, indicated that the textbook provided "little help" or "no help" to their learning experience. Sixty-three percent of respondents indicated that the

Table 1. Frequency of Pharmacy Students' Precourse and Postcourse Concerns About Taking a Course Delivered in a Blended-Learning Format (precourse, n=26; postcourse, n=23)

Concerns	Precourse Frequency	Postcourse Frequency
Questions not answered efficiently or immediately online	7	3
Availability of print copies of course materials	5	0
Ability to understand complex material online	3	0
Time management/Personal organization	3	4
Course schedule/Requirements	2	0
No concerns indicated	2	15
Theoretical problems	1	0
Layout of online material	1	0
Extra work	1	0
Technology/Internet	1	0

face-to-face problem-solving tutorials were a “great help.” Interaction with both the instructor and their peers appeared to be of great importance to students and key to supporting their individual learning. Over 80% of respondents indicated that the face-to-face interaction with the instructor during tutorials provided “much help” or “great help,” with all students indicating the sessions provided some degree of help. Although a significant portion of respondents (29%) indicated that they did not interact with the instructor during office hours, of those who did, 97% reported doing so was “helpful.” Twenty-five percent of students reported that they did not interact with the instructor online, but of those who did, 78% indicated the experience was at least “moderately helpful”. Similarly, about 25% of students responded that the item regarding online interaction with peers did not apply to them, but of those who did interact with peers online, 70% found it “moderately helpful” or better. Of those students who worked with peers outside of class, all indicated this collaboration was “helpful”, with 50% indicating it provided them “great help.”

Responses to Postcourse Open-ended Questions.

For the item concerning which aspect of the blended course was the most effective for their learning experience, the majority of students indicated they enjoyed choosing when they would watch their lectures and not having to attend regularly scheduled lectures (Table 2). Students also indicated enjoying the ability to pause and replay the online lectures until they reached a level of understanding. When asked to comment on which aspect(s) of the blended course

Table 2. Comments Received From Pharmacy Students Regarding the Most Effective Aspect of a Blended Learning Course, n=65

Response	Frequency
Flexibility of setting pace and choosing when lectures will be watched	20
Ability to pause and replay lectures/online material	11
Tutorials	7
Course organization/timing	7
Assignments and Problem sets	3
Online lectures/modules	4
Availability of face-to-face contact with instructor	4
Print copies of online modules	1
Free time	2
Discussion board	2
Online videos	2
Instructor	1
Examples given at the end of lectures	1

proved to be the least effective for their learning experience, the most common response was lack of face-to-face time with both the instructor and peers (Table 3). Discussion boards provided students an opportunity to communicate with one another as well as the instructor; however, some students complained about the relevance of the questions posted as well as the length of time it took to obtain a correct answer. Several of the comments and suggestions given by students to improve the course coincided with student responses regarding the least effective aspect of the course (Table 4). Students believed that including a greater variety and amount of assignments and problem sets would improve the course and their overall learning experience. Students’ comments and suggestions for others who have never taken a blended format course included: develop time management/personal organization, remain open-minded to the concept of a blended course; and recognize the utility of problem sets (Table 5).

DISCUSSION

Our approach to the teaching of basic pharmacokinetics was to deliver the course content completely online and to have face-to-face problem-solving tutorials with the instructor. Based on student responses, enthusiasm for this blended method of course delivery increased, as did enthusiasm for interaction with the online course modules and for face-to-face interaction with the professor during problem-solving sessions. There is, however, no basis to report an increase in enthusiasm for interacting with the instructor online through e-mail or discussion forums in

Table 3. Comments Received From Pharmacy Students Regarding the Least Effective Aspect of a Blended Learning Course, n =23

Response	Frequency
Limited face-to-face interaction with instructor and peers/no immediate responses to questions	3
Discussion boards	2
Lectures too long	2
Textbook/Online textbook	2
Correlation between problem sets/assignments and test questions	2
Material too difficult to learn online	2
Connection between theory and application	1
Organization of online course content	1
Internet access	1
Course organization/timing	1
Lack of different perspectives	1
Tutorials too short	1
Week 5 – clearance week	1
None	3

Table 4. Pharmacy Students' Suggestions and Comments for Improving a Blended Learning Course, n = 20

Ways to Improve the Course	Frequency
More and a greater variety of assignments/practice and textbook questions	3
Greater amount of time needed to complete course assignments	2
Greater diversity of material covered in tutorial	1
Single tutorial day/more tutorial time	2
More time spent teaching how to solve problems	1
More practical course material	1
More face-to-face interaction with professor	1
More time spent on Week 5	1
Better correlation between examples, assignments and tests	1
Reduce length of lectures	1
None	6

this course. This conclusion is supported by the analysis of the matched, paired precourse and postcourse responses as well as the qualitative results, which strongly suggested that student concerns about the format were, for the most part, not realized. Having both open-ended and close-ended questions in the questionnaire provided complementary data to more adequately assess student attitudes. This approach helped substantiate the findings despite the small class size (n = 89); the somewhat disappointing questionnaire response rate (75% of students completed the precourse questionnaire and 55% completed the postcourse questionnaire); and the low number

Table 5. Comments Received in Response to the Question: "What advice would you give to a student who is taking a blended course for the first time?" (n=48)

Advice for Students	Frequency
Follow course schedule and stay organized	18
Complete all questions, assignments, and problem sets	5
Remain open minded to the concept of a blended course	5
Complete problem sets before tutorial	3
Use all available resources	3
Finish work independently prior to discussing with classmates	3
Pause and replay online modules/lectures	3
Ask questions	2
Take detailed notes	2
Complete course requirements sooner than advised by course schedule	1
Space out time spent watching lectures	1
Attend tutorials	1
Persevere	1

of individual matched precourse and postcourse questionnaire responses (n = 28).

Overall, student opinions of the course and the blended format used for this course were positive. There was a large increase in the number of students who indicated no concerns at the time of the postcourse questionnaire, from 2 to 15, which suggests that many of their precourse concerns were remedied or that their original concerns never materialized. Given that 88% of the class had never taken a blended course, many of these concerns likely arose because this method of teaching was unfamiliar to students. Concerns that decreased in frequency included: having questions answered online instead of immediately in class, the availability of print copies of lecture notes, the ability to understand complex material online, and the course schedule. A concern that increased between the beginning and end of the course was time management/personal organization. Students were required to watch lectures and complete problem sets before their tutorial but did not have to follow a typical course schedule that included attending weekly in-class lectures; this type of concern is likely present for most courses that require students to personally manage the time they spend learning course material. Students' comments and suggestions for others who have never taken a blended format course included: develop time management/personal organization, remain open-minded to the concept of a blended course; and recognize the utility of problem sets.

Other aspects of the course that students found to be effective were the flexibility of setting one's pace and choosing when lectures would be watched. A closely related item that a good portion of students thought was effective was the ability to pause and replay lectures and other online material. This finding is unsurprising and has been previously reported in the literature.^{2-6,15,27}

Face-to-face interaction with both the instructor and peers was highly rated in this course; most students found these interactions provided a moderate to great amount of help. This seems to be the greatest strength of blended formats over fully online courses. Although students consistently appreciate the flexibility of the time and pace of learning online, student feedback in a Web-based human nutrition course for pharmacy students suggested that the students would have understood the course concepts and materials better in a traditional classroom than in the fully online course.²⁷ Crouch found that the online components of their blended cardiovascular pharmacotherapy course were well received by students and enhanced long-term knowledge.¹⁶ However, the students valued the face-to-face discussions in the course and this face-to-face component had a significant impact on quiz scores, which were higher for those who had engaged in face-to-face

case discussions than for those who had participated in online group cases. Boje et al found that although students were enthusiastic about the use of a virtual biotechnology laboratory in a blended pharmacy course, they preferred face-to-face discussion over asynchronous discussion boards.¹⁵ Other instructors have reported challenges with managing course communications through e-mail and the use of online discussion forums to answer questions.²⁷ Our study suggests that students prefer face-to-face interactions for asking questions and having questions answered over online communication mechanisms with each other and the instructor. At our school, these face-to-face interactions are easy to attain as the instructor's office is in the same building as the classrooms that students are using for their other courses and many students spend most of their day in this building. Under these circumstances it is reasonable that students would gravitate towards human rather than technically mediated interaction when communicating with peers and the instructor.

Garrison and Kanuka discussed the transformative potential of blended courses through the formation of "communities of inquiry"⁹ consisting of 3 integrated components: cognitive, social, and teaching presence.⁹ Interactions between students and between a student and the instructor, both online and face-to-face, provides the "social presence" component in their framework and can rely on the effective use of asynchronous communication tools, such as e-mail and discussion forums, in blended and online courses. When students and their instructor are situated in the same location it makes sense to support the social presence through face-to-face interactions, while the teaching presence and cognitive presences can be supported through online teaching modules. Students can interact with the course concepts in the modules individually or collaboratively, with one or several peers, depending on their learning preferences, and move through the modules at their own pace and at a time that fits their schedule.

Constructivist learning theory highlights the importance of social and collaborative learning experiences, so not surprisingly, face-to-face interactions with peers and face-to-face contact in tutorials or office hours with the course instructor would be important to the learning experience of students in this type of problem-solving course. Vygotsky's well known theory of the "zone of proximal development" outlines how learning involves social discourse between peers and how independent problem solving is learned through example by interacting with experts.²⁸ Although online discussion forums are effective at promoting reflective activities, face-to-face discussions are better suited to situations where students are learning directly from each other or from an expert instructor.²⁹ In our course, the feedback from students indicates that the face-to-face time

is highly valued and provides an essential element that would be lost in a fully online course where asynchronous communications would be used. In this blended course it was a logical and effective choice to put the concepts and self-assessments online, but keep the face-to-face components for highly interactive, instructor-led problem-solving tutorials. Our strategy also promotes 2 of the much-cited good practices of undergraduate education: it encourages contact between students and faculty members and develops reciprocity and cooperation among students.³⁰

While not the focus of this study, there was evidence for learning. Students were asked about the gains they made in meeting the course objectives (Appendix 1). The modal response for all course objectives was "good gain" or a 4 on a 5-point Likert scale, with 5 being the greatest gain (frequencies not shown). Since this was the first offering of the course and there was no strictly in-class previous offering, assignment and examination grades could not be compared between teaching methods.

For others considering teaching using a blended approach with course content delivery completely online, the preparation required is at least equal to in-class preparation time the first time the course is offered. It requires a certain level of comfort and problem-solving skills with incorporated softwares. There were no formal lectures as the course modules provided the "didactic" part of the course. However, student contact time was not reduced for the instructor. Although 5 hours of office hours were posted, and discussion forums were made available for questions, the instructor had students in her office at least 8 hours per week, usually concentrated around a graded assessment due date. The instructor also led two 1-hour problem-solving sessions on Fridays, with half the class participating in each. We suspect that these face-to-face interactions were richer from a student perspective than time spent in the lecture hall as they were much more student-centered. Students came to office hours and tutorial sessions with their own questions and were able to delve into the specific challenges that they were encountering with the course concepts, ask questions, and learn from the instructor as well as from each other. Future modifications of the course may include two 1.5-hour tutorials as opposed to two 1-hour tutorials. This would allow extra time for questions as well as time for the instructor to review more difficult concepts. Students also indicated that more problems sets could be posted with answer keys for practice. A question bank could be developed that students could use for examination preparation.

SUMMARY

Student enthusiasm for the blended method of course delivery, interaction with the online course modules, and

face-to-face interaction with the professor during problem-solving tutorials increased significantly between the beginning and end of a 6-week blended pharmacokinetics course. Overall students' concerns about blended learning decreased; however, they became more concerned about and aware of the importance of managing their own time and being organized to complete the online course components on time, get the most out of the weekly course tutorials, and be prepared for assignments. Students placed a high value on face-to-face interactions with the instructor and with their peers for asking questions about the problem-solving aspects of this course. Since students showed both evidence of learning and enthusiasm for the blended format, this method could be considered for other courses or course sections within a pharmacy curriculum, provided the content was suitable. However, the face-to-face aspect is expected to be paramount in assuring learning gains regardless of the content.

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Appendix 1. Questions from the Precourse and Postcourse Questionnaires

Questions that were asked in both questionnaires:

What is your level of enthusiasm for the following aspects of this blended course? (1= very enthusiastic, 2= enthusiastic, 3= neutral, 4= somewhat enthusiastic, 5= not enthusiastic)

Learning in a blended course environment

Interacting with course learning modules online

Interacting with your instructor online through email and discussion forums

Interacting with your instructor in face to face problem solving sessions

Have you ever taken a course with a blended format before? Yes/No

Have you ever taken a fully online course before? Yes/No

Open-ended #1: Pre-course: If you have concerns about taking a course in a blended format, please outline these concerns.

Post-course: If you had concerns at the beginning of term about taking a course in a blended format, are those concerns still present?

Questions that were asked only in the post-course questionnaire:

How much did each of the following aspects of the course help your learning? (1=No Help, 2=Little Help, 3= Moderate Help, 4= Much Help, 5= Great Help)

Interacting with course materials online

Interacting with self-assessment activities online

Participating in face-to-face problem solving tutorials

Reading a text book

Open ended #2: Use the text area below if you want to make comments on how the course activities helped your learning.

How much did each of the following aspects of assessment help your learning? (1=No Help, 2=Little Help, 3= Moderate Help, 4= Much Help, 5= Great Help)

Completing assignments

Instructor feedback to assignments

The number and spacing of assignments

Completing the midterm

Instructor feedback to the midterm

How much did each of the following resources help your learning? (1=No Help, 2=Little Help, 3= Moderate Help, 4= Much Help, 5= Great Help)

Course and module objectives

The online textbook

The print textbook

Online materials for each module

Information Sheets *E.g. One component model equations*

How much did each of the following aspects of the course help your learning? (1=No Help, 2=Little Help, 3= Moderate Help, 4= Much Help, 5= Great Help)

Interacting with the instructor during tutorials

Interacting with the instructor during office hours

Interacting with the instructor online

Interacting with peers online

Working with peers outside of class

As a result of you work in this class what gains did you make in your understanding of each of the following? (1=No Gain, 2=Little Gain, 3= Moderate Gain, 4= Good Gain, 5= Great Gain)

The role of formulation, drug physico-chemistry and physiology on the absorption profile and bioavailability of drug administered by non-intravenous routes.

How the factors driving distribution volume affect drug pharmacokinetics.

The clearance concept with respect to plasma and intrinsic clearance as well as metabolite and urinary kinetics.

The derivation of relevant pharmacokinetic parameters by mathematically describing a pharmacokinetic profile following single intravenous and non-intravenous administration.

How, given relevant pharmacokinetic parameters, one can apply pharmacokinetic equations to calculate drug concentrations in biological fluids following bolus, infusion, single and multiple administrations.

Connecting class ideas with other knowledge.

Open ended #3: Please comment on how the way this class was taught helps you remember key concepts.

Indicate your level of satisfaction with the course related technology. (1 = Extremely Unsatisfied, 2= Unsatisfied, 3= Neutral, 4= Satisfied , 5= Extremely Satisfied)

Ease of navigation of the website

Using the online environment to support your learning

Were the course expectations clearly identified for you? Yes/No

Open ended #4: What was the most effective aspect of this blended course? Why?

Open ended #5: What was the least effective aspect of this blended course? Why?

Open ended #6: Do you have suggestions or additional comments for improving this blended course?

Open ended #7: What advice would you give to a student who is taking a blended course for the first time?