

A Student-Driven Nutritional Biochemistry Recitation Course Demonstrated Better Grades and Acceptability among Enrolled Students



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Abstract

To determine the acceptability and effectiveness of a student-driven recitation course in enhancing student learning of nutritional biochemistry, student data derived from upper-level dietetics and human nutrition majors was compared between those enrolled in the required three-credit hour lecture course only (n=84) and those enrolled in the lecture plus optional supplementary one-credit hour recitation course (n=89). Both lecture and recitation were led by the same course instructor. Recitation students were required to post questions to the recitation course wiki, which the instructor used to generate discussion and further questions from the students during recitation. Results demonstrated that final course grade averages were higher among students enrolled in recitation, $83.5\% \pm 10.1$ vs. $78.8\% \pm 11.7$ ($p < 0.05$) and attendance was better, 6.2 ± 1.2 vs. 5.6 ± 1.4 days (7 random attendance days, $p < 0.001$). Over 70% of students found recitation to be helpful or very helpful in clarifying class material and preparing for course exams ($p < 0.001$). Two-thirds of students stated they would recommend recitation to a peer. These positive results indicate the student-driven recitation was delivered appropriately to meet student learning needs in a manner that required minimal course preparation by the instructor.

Introduction

Challenging science-based coursework such as advanced courses in biology, chemistry, physiology, genetics and biotechnology are common requirements in undergraduate agriculture disciplines. In dietetics, animal science, food science and human nutrition programs, nutritional biochemistry is often considered a difficult course. Such rigorous science-based coursework can challenge and intimidate students, perhaps contributing to under-performance and a tendency towards

memorizing, rather than truly learning, important concepts (Minasian-Batmanian and Lingar, 2006). Indeed, starting in elementary school, children often have a difficult time grasping the application of biology and chemistry (Carvalho et al., 2004). This is particularly the case in nutrition where students are expected to relate biochemical pathways occurring as the result of food intake to subsequent health implications, such as diabetes or obesity (Rowlands, 2004).

This research study aimed to evaluate the acceptability and effectiveness of an optional one-credit hour student-centered recitation in a high (n= 173) enrollment undergraduate course. While others have evaluated a wide variety of innovative approaches to teaching biochemistry, limited research is available on the acceptability and efficacy of a student-driven recitation or workshop. This study is unique in that (1.) the lecture instructor was also the recitation instructor and (2.) the material discussed during recitation was student-driven in that it was based on student questions posted to the course wiki prior to class rather than the instructor providing in-class worksheets or reviewing homework problems. This manner of delivery required little preparation time for the instructor while focusing on challenging concepts as perceived by students. Knowledge gained from this study could be utilized in making decisions about allocation of resources (i.e. faculty time) in teaching challenging coursework. Indeed, while many innovative classroom approaches prove successful, some are too resource intensive to sustain (Anderson et al., 2005).

Methods

Study subjects (n=173) consisted of junior and senior students enrolled in a three-credit hour undergraduate nutritional biochemistry lecture course that was required for human nutrition and dietetics majors.

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The one-credit hour nutritional biochemistry recitation course was an optional supplementary course open to all students enrolled in the lecture. Two comparable sections of recitation led by the course instructor were offered one day per week (n=43 and n=46 students). Each week, two students were assigned to post a minimum of one biochemistry-related question to their respective recitation section wiki, which was available through the course learning platform. As well, all recitation students had the opportunity to anonymously post questions to their respective recitation wiki at any time throughout the semester. At all times during the semester, the posted questions were available for viewing by students enrolled in recitation. The course instructor started each recitation class by displaying the posted wiki questions on the screen and initiated discussions by probing the class to answer each wiki question along with other questions that were raised during recitation.

At the end of the semester, all students in the nutritional biochemistry course were invited to earn bonus points by taking an online anonymous survey. The survey included 22 questions pertaining to their study habits and if applicable, satisfaction with the delivery style of the student-driven recitation in enhancing their learning of lecture material, clarifying class material and preparing them for exams. A total of 168 surveys were completed, which included 88 students enrolled in recitation.

To assess student learning between those enrolled and not enrolled in recitation, final course grades were compared. Course grades were calculated based on averaging four exams and four online quizzes. Random in-class attendance was taken in lecture seven total times throughout the semester and was compared between groups.

The human nutrition and dietetics students enrolled in the fall nutritional biochemistry class were required to take the follow-up advanced nutrition course. Therefore, to evaluate retention of macronutrient metabolism knowledge, the exam 2 grades from the follow-up advanced nutrition course (spring 2015) were compared between students enrolled and not enrolled in the biochemistry recitation the previous semester (n=140 students). Exam 2 material covered the application of macronutrient metabolism that was included in detail in the pre-requisite nutritional biochemistry course (fall 2014). The University of Kentucky Institutional Review Board approved the study protocol and all participants provided written informed consent prior to participation in the study.

Data was analyzed using SAS version 9.3 (SAS Institute Inc., 2012). Descriptive statistics including means, standard deviation and frequencies were calculated for all students enrolled in the required nutritional biochemistry class, those enrolled in recitation, and students in lecture only. The Shapiro-Wilk test for normality revealed the data to be normally distributed (p> 0.05). Significant associations between continuous variables (course grades, cumulative GPA, and atten-

Table 1. Descriptive Statistics of All Students Enrolled in a Required Nutritional Biochemistry Lecture Course.

	All Students in Required Lecture Course (N=173)	p-value ^z
Major (%)		***
Dietetics	39.9	
Human Nutrition	56.6	
Other	3.5	
Enrolled in Recitation (%)		
Cumulative GPA (SD) ^y	3.21 ± 0.4	
Mean Final Course Grade (Grade ± SD)	81.2 ± 11.1	
Course Grade Distribution (%)		***
A	23.7	
B	35.3	
C	26.6	
D	11.6	
F	2.89	
Mean Random Attendance (Days ± SD) ^x	5.91 ± 1.3	
Random Attendance Distribution (%)		***
0 – 1 days present for random attendance	1.73	
2 -3	4.05	
4 -5	23.7	
6 – 7	70.5	
Mean Exam 2 Grade from Advanced Nutrition Course (n= 140, Grade ± SD)	76.6 ± 13.7	
Advanced Nutrition Exam 2 Grade Distribution (%)		*
A	22.9	
B	25.7	
C	23.6	
D	12.1	
F	15.7	
Do you study by yourself or with a group?		***
Mostly with a group and some on my own	13.7	
Mostly on my own and some with a group	57.1	
On my own	29.2	
When do you typically start studying for an exam? (%)		***
Daily basis	8.3	
When review sheet is available	23.21	
2 weeks before exam	14.3	
1 week before exam	44.1	
Other	10.1	
Did you watch the supplemental videos posted on the Blackboard website? (%)		***
Yes	73.2	
No	26.8	
Did the videos enhance your learning? (%)		***
Yes, most of the time	56.1	
Sometimes	41.5	
Not really	2.4	
Did you purchase, rent or borrow the course textbook? (%)		NS
Yes	50.0	
No	50.0	
How often did you read the textbook? (n= 84)		***
≤ 1 time per month – 3 times per month	79.8	
1 time per week - daily	20.2	

^zNS, **, or *** is equivalent to non-significant, p= 0.05, 0.01, or 0.001, respectively using independent student t-tests for continuous variables and Chi Square analysis for categorical variables.

^yCumulative GPA represents the student's cumulative GPA at the start of the semester.

^xMean attendance: random attendance was taken a total of seven times throughout the semester.

dance) were determined using independent student t-tests. Chi Square analysis was used to determine significant associations among categorical variables. Significant correlations among the variables were identified using the Spearman correlation test. The General Linear Model multiple regression analysis was used to delineate the relationship among course grades, cumulative GPA and recitation. Final course grade was the dependent variable and cumulative GPA and recitation enroll-

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ment (1=yes, 2=no) were the independent variables included in the regression model. The cumulative GPA used for analysis was derived from student records and represented the pre-term GPA of students at the beginning of the fall 2014 semester before completing nutritional biochemistry. $P < 0.05$ was considered statistically significant and standardized residuals ± 1.96 indicated a contribution to a significant relationship between groups identified in the Chi Square analysis.

Results and Discussion

This study found that students enrolled in a one-credit hour optional student-centered nutritional biochemistry recitation class had better course grades, increased attendance and better study habits compared to students enrolled in the required lecture course only ($p < 0.05$, Table 2). These results agree with previous studies that have also observed positive academic achievement among students enrolled in recitation sections associated with “high-risk” courses, such as biochemistry, biology, accounting or economics (Etter et al., 2000; Marbach-Ad and Sokolove, 2000). The current study was unique because the recitation section was facilitated by the lecture course instructor, rather than a graduate assistant. Another distinctive feature of this study was the student-centered nature of the recitation course with the use of technology to facilitate recitation. This allowed students to set the pace of the recitation period and determined what material needed to be reviewed. Additionally, this course design required a minimal amount of preparation by the instructor, which is an important consideration when resources are limited.

A total of 173 students were enrolled in the required nutritional biochemistry lecture course. Of these, the majority were Dietetics and Human Nutrition majors, 39.9% and 56.6%, respectively with significantly fewer “other” majors, which consisted of Food Science students ($p < 0.05$, Table 1). The class as a whole had a cumulative GPA of 3.21 ± 0.4 and an average final course grade of $81.2\% \pm 11.1$, with 59% of students earning an A or B in the course ($p < 0.0001$). Additionally, as a class, students were present for 5.91 ± 1.3 days of the 7 days when attendance was taken (Table 1).

For this project, students enrolled in recitation were required to post class-related questions to the recitation course wiki at least 15 hours prior to the recitation period. The wiki questions were then used by the instructor to

Table 2. Descriptive Statistics of Students Enrolled in Recitation/Required Lecture Course and Students Enrolled in the Required Lecture Course Only.

	Recitation and Required Lecture Course (n= 89)	Required Lecture Course Only (n= 84)	p-value ^z
Major (%)			*
Dietetics	37.5	42.5	
Human Nutrition	62.5	50.0	
Other	0	7.5	
Enrolled in Recitation (%)	51.5	48.6	NS
Cumulative GPA (SD) ^y	3.26 ± 0.40	3.17 ± 0.40	NS
Mean Final Course Grade (Grade \pm SD) ^x	83.5 ± 10.1	78.8 ± 11.7	*
Course Grade Distribution (%)			NS
A	27.0	20.2	
B	38.2	32.1	
C	27.0	26.2	
D	7.9	15.5	
F	0.0	6.0	
Mean Random Attendance (Days \pm SD) ^w	6.2 ± 1.2	5.6 ± 1.4	**
Random Attendance Distribution (%)			*
0 – 1 days present for random attendance	1.1	2.4	
2 -3	1.1	7.1	
4 -5	18.0	29.8	
6 – 7	79.8	60.7	
Mean Exam 2 Grade from Advanced Nutrition Course (n= 140, Grade \pm SD)	78.0 ± 13.5 (n=78)	74.8 ± 13.8 (n= 62)	NS
Advanced Nutrition Exam 2 Grade Distribution (%)			NS
A	26.9	17.7	
B	25.6	25.8	
C	25.6	21.0	
D	6.4	19.4	
F	15.4	16.1	
Do you study by yourself or with a group?			NS
Mostly with a group and some on my own	10.2	17.5	
Mostly on my own and some with a group	63.6	50.0	
On my own	26.1	32.5	
When do you typically start studying for an exam? (%)			*
Daily basis	14.8	1.25	*
When review sheet is available	14.8	32.5	*
2 weeks before exam	13.6	15.0	
1 week before exam	46.6	41.3	
Other	10.2	10.0	
Did you watch the supplemental videos posted on the Blackboard website? (%)			NS
Yes	73.9	72.5	
No	26.1	27.5	
Did the videos enhance your learning? (%)			NS
Yes, most of the time	53.9	58.6	
Sometimes	44.6	37.9	
Not really	1.54	3.5	
Did you purchase, rent or borrow the course textbook? (%)			NS
Yes	51.1	48.8	NS
No	48.9	51.3	
How often did you read the textbook? (n= 84)			NS
≤ 1 time per month – 3 times per month	80.0	79.5	
1 time per week - daily	20.0	20.5	

^zNS, *, **, or *** is equivalent to non-significant, $p = 0.05$, 0.01 , or 0.001 , respectively using independent student t-tests for continuous variables and Chi Square analysis for categorical variables.

^yCumulative GPA represents the student’s cumulative GPA at the start of the semester.

^xThe significant difference between final course grade between recitation and non-recitation students remained when the General Linear Regression model included “cumulative GPA” and “recitation enrollment status” as independent variables ($p = *$).

^wMean attendance: random attendance was taken a total of seven times throughout the semester.

initiate peer-discussion and stimulate further questions during each recitation session. Students felt this manner of content delivery was helpful or very helpful in clarifying course material (73%) and preparing for exams (72%). Additionally, 66% of students reported that they would recommend recitation to a peer.

As is typical of most supplemental recitation courses, this recitation was attached to a high-risk course, rather than to students-at-risk (Etter et al., 2000). All students

in the course were invited to enroll on a volunteer basis. A total of 89 students (51.5%) from the required lecture course were enrolled in one of the two comparable sections of recitation. Recitation was composed entirely of human nutrition and dietetics majors, with no students from outside majors enrolled ($p < 0.05$, Table 3). No significant difference was found between the pre-term cumulative GPA among students enrolled or not enrolled in recitation (Table 2). This is an important finding because GPA is highly correlated with motivation, a key predictor of academic achievement (Cheng and Ickes, 2009). Data revealed that, among students not in recitation, 45% indicated that time conflicts with other classes or work was the most common reason for not enrolling ($p < 0.0001$, Table 3). As well, 25% of students did not sign up for recitation because they felt they did not need the supplemental course ($p < 0.05$). As such, students who self-enrolled in recitation were not necessarily more motivated than those that did not enroll in recitation.

Final course grade averages were higher among students enrolled in recitation, $83.5\% \pm 10.1$, compared to those not enrolled, $78.8\% \pm 11.7$ ($p < 0.05$, Figure 1). In addition, a trend emerged of the students in recitation having more A's (27% vs 20%), and B's (38% vs 32%), fewer D's (7.9% vs 15.5%) and no F's (0% vs 6%) ($p = 0.067$, Table 2). Linear regression was used to further delineate the relationship between cumulative GPA, a proxy for motivation (Romer 1993), and final course grades. The relationship of final course grades being higher among those enrolled in recitation remained significant when recitation participation and pre-term cumulative GPA were included as independent variables in the linear regression model. The regression model demonstrated that both participation in nutritional biochemistry recitation and cumulative GPA were independently associated with higher final course grades ($p < 0.05$, data not shown). The interaction term, recitation*cumulative GPA, was included in the model and was found to be insignificant thereby allowing for the

interaction term to be removed from the final model. Significant positive correlations were observed between the final course grade outcome variable and the following independent variables: recitation participation ($r = 0.21$), cumulative GPA ($r = 0.62$), and mean random attendance ($r = 0.48$) ($p < 0.05$, correlation data not shown). Also, recitation participation was moderately correlated with mean random attendance ($r = 0.23$, $p < 0.05$).

The environment provided by recitation promoted student engagement, which has been identified as a key element to increasing student performance particularly in complex science courses (Addison et al., 2009). The wiki provided an opportunity for students to participate in the recitation in a non-intimidating manner by posting questions to the course wiki outside of class. Wikis, podcasts, blogs, clickers and other web-based tools are growing in popularity in higher education and are critical to increasing student engagement while concurrently enhancing student learning (Boulos et al., 2006). In particular, wikis are commonly used in a variety of ways to promote learning in educational settings (Boulos et al., 2006). In the current study, the instructor observed

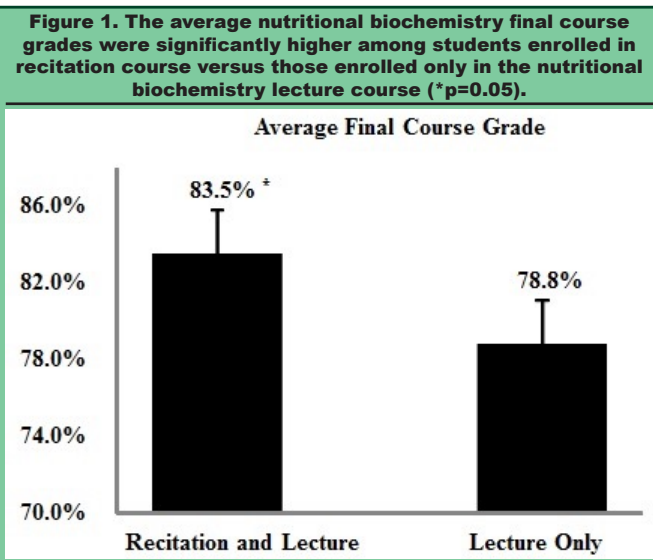


Table 3. Biochemistry Recitation Survey Results.

Survey Questions (N = 168)					p-value ^z
Would you recommend nutritional biochemistry recitation? (%)					***
Yes	65.6				
Maybe	24.4				
No	10.0				
Why did you not register for nutritional biochemistry recitation? (%) (n = 73)					*
Scheduling conflict with other classes or work	45.2				
Was not aware that recitation was offered	22.0				
Recitation was full	8.2				
Did not feel it was needed	24.7				
How helpful has recitation been to	Very Helpful	Helpful	Somewhat Helpful	Not Helpful	p-value ^z
Clarify class material?	39.8	33.0	20.5	6.8	***
Prepare for course exams?	33.0	38.6	20.5	8.0	**
Meet study partners and share resources?	20.7	18.4	32.2	28.7	NS
In general, the material presented in recitation was.....	Most of the time	Hardly Ever	Sometimes	p-value ^z	
Too basic	4.6	72.7	22.7	***	
Too complicated	11.4	42.1	46.6	***	
Too boring to listen and pay attention	15.9	43.2	40.9	*	
Too repetitive	10.2	55.7	34.1	***	
Too fast-paced	6.8	64.8	28.4	***	

^zNS, *, **, or *** is equivalent to non-significant, $p = 0.05$, 0.01, or 0.001, respectively using independent student t-tests for continuous variables and Chi Square analysis for categorical variables.

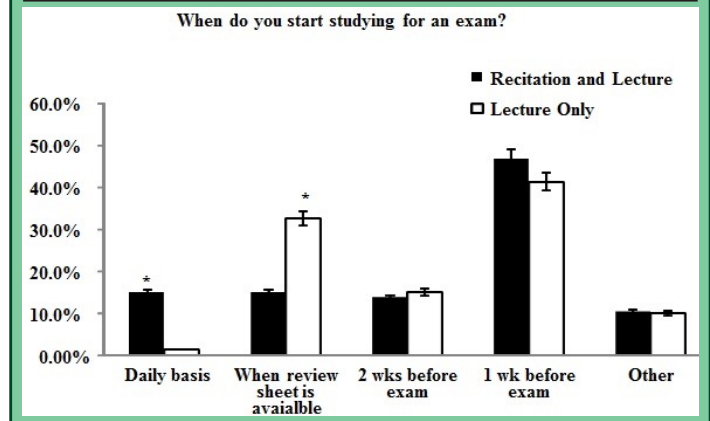
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that the majority of students posted questions to the wiki because they were assigned to post on a given day; however, questions were also posted by students not required to do so for a grade. This allowed students to set the pace and determine the material that needed to be reviewed each recitation session which ensured that any confusing points perceived by students could be discussed and clarified during recitation. In addition, the use of the wiki minimized student anxiety often associated with asking questions during class (Marbach-Ad and Sokolove, 2000). As well, the wiki relieved the awkward silence instructors may encounter after asking students if they have any questions (Kanar, 2014). Another instructor-advantage of this format is that it alleviated the need to prepare worksheets or questions for each recitation session.

In the current study, recitation feedback was provided by 88 survey respondents or 99% of students enrolled in recitation. Over 70% of students found recitation to be helpful or very helpful in clarifying class material and preparing for course exams ($p < 0.001$, Table 3). Students were positive about the delivery of recitation in that over 70% felt the material was hardly ever too basic ($p < 0.0001$) and approximately 65% reported the pace to be appropriate most of the time. Only 16% of students felt that recitation content was consistently delivered in a “boring” manner ($p < 0.05$) and even fewer, <11%, rated material as consistently being too complicated or repetitive ($p < 0.0001$). Students were generally positive about recitation with 66% stating they would recommend recitation to a peer and only 10% stating they would not ($p < 0.0001$, Table 3).

Previous research has shown student engagement in regular acts of studying to be associated with increased student knowledge and academic performance (Crede and Kuneel, 2008). When evaluating study habits ($n = 168$ survey respondents), the current study showed that over 10 times the number of recitation students were significantly more likely to study on a daily basis compared to those not enrolled, 14.8% vs. 1.25% ($p < 0.05$, Figure 2). Conversely, over twice the number of students not enrolled in recitation began studying once the review sheet was available, 32.5% versus 14.8% of those enrolled in recitation ($p < 0.05$, Figure 2). When considering all students enrolled in nutritional biochemistry, 44% of students began studying about one week before the exam ($p < 0.0001$, Table 2). Approximately 57.1% of students reported preferring to study on their own with some study time spent with one or more people ($p < 0.0001$, Table 1). However, whether a student studied alone or with a group did not impact course grades (data not shown). Among those enrolled in recitation, 39% reported that recitation was helpful or very helpful for meeting study partners (Table 3). Therefore, the added benefit of recitation facilitating study groups complimented well with the preference of the whole class to study on their own as well as with a group to prepare for exams. This style of exam preparation was not a surprising result as the instructor

Figure 2. Students enrolled in the recitation course were more likely to study on a daily basis compared to students enrolled in only the nutritional biochemistry lecture course, whereas students enrolled in the lecture course only were more likely to initiate studying once the review sheet was available (* $p < 0.05$).



emphasized throughout the semester that studying with others could enhance their comprehension of nutritional biochemistry.

Attendance, as assessed by random attendance taken seven different days during the semester, was significantly higher among recitation students, 6.2 ± 1.2 vs. 5.6 ± 1.4 days ($p < 0.001$). The data revealed that attendance was significantly and strongly correlated with the final course grade, $r = 0.48$ ($p < 0.05$, data not shown). This demonstrates that attendance itself was a critical factor in student success. Interestingly, there was a moderate correlation between recitation participation and increased attendance ($r = 0.23$, $p < 0.05$, correlation data not shown). Therefore, it is not unreasonable to suggest that participation in recitation contributed to success by increasing the likelihood of students attending class more regularly thereby increasing their exposure to course material beyond that of students not enrolled in recitation. As noted by Romer (1993), the effect of attendance on student performance is difficult to isolate and assess, but increased class attendance does appear to be significantly associated with course grades.

The effect of class size on student achievement in higher education is still a matter of debate (Kokkelenberg et al., 2008), but several studies have demonstrated that smaller sized classes create an environment geared towards critical thinking and advanced problem-solving (McKeachie et al., 1990). The recitation classes were one-quarter the size of the regular lecture course and allowed for the sessions to be directed towards critical thinking and problem-solving on a regular basis. This may have contributed to the success of recitation because the students enrolled in lecture only did not have the opportunity to do this as frequently.

The student-centered learning style offered by the biochemistry recitation class has been shown to increase retention of course knowledge (Collins and O'Brian, 2003). To assess retention, the current study compared the grades of an exam given in an advanced nutrition course that was offered the spring semester following

the fall nutritional biochemistry course and taken by 80% of the students. The exam in the advanced nutrition course tested the important concepts of macronutrient metabolism that was covered in detail throughout the biochemistry course. The results demonstrated that the average score on the advanced nutrition exam was trending towards being higher among students that were enrolled in recitation the previous semester, 78.0 ± 13.5 vs. 74.8 ± 13.8 (Table 2). Furthermore, students enrolled in recitation had more A's and fewer D's on the advanced nutrition exam ($p = \text{NS}$, Table 2). A significant finding may have emerged if 100%, rather than 80%, of the students that took the fall biochemistry course would have taken advanced nutrition the subsequent semester. While a required course for dietetics and human nutrition students, the course is not required for food science students (3.5% of original biochemistry course roster) and some students chose to take the advanced nutrition course at a later time. This data suggests that there may be a relationship between enrollment in recitation and subsequent achievement in a follow-up course, but further research is needed.

There were no differences between groups regarding the tools used to supplement their learning and studying. Both groups were similar in their use of the instructor-posted videos that were available on the nutritional biochemistry course online learning platform. Additionally, both groups infrequently used the textbook (Table 2). An interesting finding pertaining to all of the students enrolled in the nutritional biochemistry lecture course was that the vast majority of students preferred to supplement their learning of macronutrient metabolism with instructor-posted videos rather than the optional course textbook.

Limitations

Overall, this study found that students enrolled in a supplementary nutritional biochemistry recitation course that used a student-focused approach had significantly increased final course grades beyond students enrolled in the lecture course only. The study, however, did have several limitations. For one, students were not randomly assigned to enroll in recitation which could introduce a sample bias whereby more motivated students took the recitation course and, therefore, would be more successful in the course regardless of the recitation. Despite such potential, this research showed no significant difference in cumulative GPA, a proxy for motivation, between the groups. As well, when GPA was included in the regression model, biochemistry recitation remained independently associated with increased course grades.

Due to limited resources an alternative control recitation section was not offered. Despite not offering a control recitation, the positive results of the current study suggests that delivering recitation in this student-driven manner works as well as traditional recitation courses. A limitation pertaining to the requirement of posting a question to the wiki is that students may have posted

a question because it was an assignment, rather than because they truly needed a question answered. While a limitation to the research, from an instructional standpoint, posting of any questions provided an opportunity to initiate classroom discussion and foster student learning. As far as the significant findings of increased studying and attendance among recitation students, it was beyond the scope of the study to assess the quality of the time spent studying or to delve into why students did not attend class. Previous research demonstrates the positive effects that study time and class attendance have on student achievement. Therefore, it is not unreasonable to associate these characteristics with student achievement (Crede and Kuneel, 2008). The current study did not assess the validity or reliability of the exams and assumed the exams included information that students had been taught.

Summary

In conclusion, students enrolled in a student-driven nutritional biochemistry recitation course had significantly higher final course grades and better attendance and study habits compared to those not enrolled in recitation. Supplementing student learning of nutritional biochemistry with an effective recitation course is critical for student success because nutritional biochemistry contains the foundational knowledge critical to the health, animal and food science fields of study.

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