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Special Topics

Assessing the effect of case-based teaching compared with lecture-based teaching on students' knowledge and perceptions in a senior undergraduate dairy cattle management course

Logan Ferree,[†] Noa Román-Muñiz,[†] Lily Edwards-Callaway,[†,] Tonya Buchan,[‡] JenniferTodd ,[‡] and Catie Cramer[†,1,]

[†]Department of Animal Sciences, Colorado State University , Fort Collins, CO 80521, USA
[‡]The Institute for Learning and Teaching, Colorado State University , Fort Collins, CO 80521, USA
[1]Corresponding author: Catie.Cramer@colostate.edu

ABSTRACT

Animal science students need to apply the knowledge acquired during their degree program to real-life scenarios in future careers. Little to no research exists evaluating the effects of case-based (CB; material presented as a case study) and lecture-based (LB; material presented as a lecture) teaching in animal science in higher education. The objectives of this study were to determine the effects of CB and LB teaching methods on student performance and to assess students' attitudes toward CB and LB teaching methods in a senior dairy cattle management course. A cross-over study design was conducted over two course modules (1 = "calf health" and 2 = "lameness") with a washout period of 2 wk. Students (n = 25) were randomly assigned to CB or to LB in module 1 and received the other method in module 2. Students completed a pre- and post-quiz in each module that consisted of 10 multiple-choice questions and 3 short-answer questions. Three separate linear mixed regression models were used to assess the effect of teaching method (CB or LB; predictor) on three different continuous outcomes for student performance: change (post-score – pre-score) in short-answer quiz scores, change in multiple-choice quiz scores, and the change in total quiz scores. Students completed an attitude assessment after each module that consisted of 8 Likert-scale statements and 2 free-response questions. Data were deidentified, and two researchers blinded to students' CB or LB status analyzed free responses to identify themes. A logistic regression, which controlled for module and included student as a repeated measure, was used to determine if the proportion of students who agreed (outcome: yes/no) with each Likert-scale statement was different between CB and LB. There was a tendency for CB teaching methods to improve change in multiple-choice quiz scores (P = 0.06). The change in total quiz scores and the change in short-answer quiz scores did not differ between CB and LB groups (P > 0.1). For the survey statements "I enjoyed the teaching method used in this module" and "I wish this teaching method was utilized in more of my classes," more students in LB agreed than in CB (P < 0.05). The themes preference, perceived benefits, and perceived drawbacks were mentioned in 80%, 44%, and 28% of CB comments, and in 84%, 40%, and 18% of LB comments, respectively, and suggest that students enjoy case studies but prefer to receive information via lecture first.

Key words: animal science teaching, lecture, scholarship of teaching and learning, undergraduate teaching

INTRODUCTION

Traditional lecturing, a teaching method in which an instructor presents course content to students, is one of the predominant teaching methods utilized in higher education (Yuan et al., 2011; Roehl et al., 2013; Mesthrige et al., 2020). Lecture can be utilized to efficiently communicate large amounts of information to numerous students (Brown and Race, 2005; Charlton, 2006) and can reduce the cognitive load in students presented with new information by allowing students to focus on points emphasized by the instructor (Charlton, 2006; Race, 2007). A lecture can also provide students the opportunity to interact with the instructor by asking questions (Brown and Race, 2005). Lecture may be sufficient in promoting cognitive learning at the levels of remembering and understanding but may not be effective in promoting cognitive learning at the higher levels of application, analysis, synthesis, and evaluation (Bligh, 2000; Charlton, 2006). Animal science students who continue on to careers in agriculture need a few specific professional skills such as self-reliance, problem-solving, and decision-making (Wattiaux, 2009). The development of these professional skills could arise from higher-order cognitive learning (i.e., application, analysis, synthesis, and evaluation) in animal science degree programs to equip animal science students with the necessary skills needed in their future careers (e.g., self-reliance, problem-solving, and decision-making; Wattiaux, 2009). Pedagogical research in healthcare fields suggests that case-based (CB) teaching may be an ideal teaching method for animal science students needing to develop professional skills similar to those of healthcare students (e.g., profession-specific skills, knowledge creation capacity, and theoretical knowledge; Hanson and Sinclair, 2008). Students in healthcare need to be able to solve a problem when presented a case (i.e., treat a patient) much like animal scientists need to be able to solve a

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problem when presented a case (i.e., investigate the cause of profit loss on a dairy). Given that students in healthcare fields require skills similar to students in animal science such as problem-solving, critical thinking, decision-making, and the ability to apply knowledge to real-world situations (Hanson and Sinclair, 2008; Wattiaux, 2009), we can glean potentially useful pedagogical practices from the healthcare fields to apply to teaching animal science students in higher education.

There is not a universal definition of CB teaching, but it is understood that CB methods are referring to the implementation of active learning strategies such as case studies in addition to facilitated hands-on activities to simulate a learning experience as similar to real-life scenarios as possible (Thistlethwaite et al., 2012). Data regarding pedagogical methods in animal sciences are sparse to nonexistent. Case-based teaching is suggested to enhance students' motivation to learn and results in a deeper level of understanding (Gal et al., 2018). Case-based methods can also optimize learning and performance on both CB and non-CB items when CB methods are used in addition to traditional lectures (Panja et al., 2013). There is an agreement in the existing literature that CB methods result in greater development of profession-specific and problem-solving skills (Hanson and Sinclair, 2008; Panja et al., 2013). The presumed benefits of CB teaching methods should be weighed against the perceived drawbacks (e.g., heavy workload and time commitment) before the implementation in curriculum (Gal et al., 2018). It is important to understand how teaching methods impact the development of students' skills, knowledge, and attitude in the classroom. To our knowledge, there is no research evaluating the efficacy of CB teaching methods in animal sciences in higher education. Case-based teaching could be a powerful tool in animal science classrooms in higher education to enhance students' learning experience. Before implementation, it is necessary to determine if CB teaching positively affects student performance and how students perceive this teaching method. Therefore, the objectives of this study were to determine the effects of CB vs. lecture-based (LB) teaching methods on student performance and to assess student attitude toward CB and LB teaching methods in a senior dairy cattle management course at a land-grant university.

MATERIALS AND METHODS

Our study utilized existing literature to design and implement a cross-over design study in a senior dairy management course at a land-grant university in the United States consisting of undergraduate and graduate students. This study utilized two content modules (module 1 = "calf health" and module 2 = "lameness") with a washout period of 2 wk in between content modules. Undergraduate and graduate students pursuing a degree in Animal Sciences (n = 25) were randomly assigned, using a random number generator in Microsoft Excel (Microsoft Corp., Redmond, WA), to either CB or LB teaching methods for module 1 ("calf health"). Students then received the opposite teaching method in module 2 ("lameness"). Due to COVID-19 university restrictions, the course was taught in a hybrid format which included prerecorded lectures posted on an online learning management system (Canvas; Instructure, Inc., Salt Lake City, UT) and an optional in-person lab once per week. The lab was also recorded and posted online for students to view.

Institutional Review Board Approval and Participant Recruitment

This study was approved by the Institutional Review Board (IRB) at Colorado State University (protocol # 1952). A member of the research team not involved with the course or data analysis presented the study participation information to the students in the course via video recording posted on an online learning management system. Informed consent was obtained from students by submitting a signed participant agreement (n = 25) and a 1.5% bonus was offered to students for submitting the signed agreement, regardless of participation status. Consent indicated that students opted to allow the research team to use assignment scores and responses for analysis. The course instructors were blinded to the study participation status of students, and data were deidentified by the same member of the research team that presented the study participation information prior to data analysis. All students, regardless of participation in research, completed the same modules and assignments as part of the coursework.

Course Content

Course materials (case studies, lectures, student materials such as notes and handouts, and quizzes) were posted on an online learning management system for students to access during the two course modules, for both CB and LB groups. Modules were designed to require similar effort and time (approximately 3 h) and challenge similar levels of cognitive learning defined using Bloom's Taxonomy (Krathwohl, 2002). The same content and learning objectives were covered for CB and LB groups within a module.

Students, regardless of treatment and module, received module content via an online learning management system on a Monday and had the option to attend a 75-min in-person lab section on Friday. Due to guidelines for COVID-19, students could attend this lab section in person, synchronously via Microsoft Teams (Microsoft Corp., Redmond, WA) or asynchronously via a Microsoft Teams (Microsoft Corp., Redmond, WA) recording posted on an online learning management system. The lecture (LB) or the case study (CB) was presented by the course instructor during the 75-min lab section.

Module 1 ("calf health") focused on bovine respiratory disease (BRD) in dairy calves. The learning objectives in module 1 targeted the following cognitive learning levels: remembering, understanding, evaluating, and analyzing (Krathwohl, 2002); learning objectives were the same for both CB and LB. Case-based teaching materials given on a Monday consisted of a "student materials" document containing written paragraphs of information providing students with the definition of BRD, risk factors for BRD, BRD identification strategies, BRD treatment, management strategies of BRD in dairy calves, links to online reading materials relative to BRD in dairy calves, and the calf health case study containing guiding questions. Students in CB were instructed to read the "student materials" and review the calf health case study prior to the lab section on Friday. The calf health case study included a descriptive scenario that asked students to evaluate management factors associated with BRD (e.g., nutrition, colostrum management, ventilation, weather, and more). The calf health case study included questions that were designed so that students had to actively seek out information (Anderson and Krathwohl, 2001) from the "student

materials" to evaluate the management factors described in the scenario and their potential effect on BRD. During the 75-min lab section, a course instructor guided the CB students through the questions in the calf health case study, and students were able to converse with peers and the instructor while answering the calf health case study questions. The materials for the LB group in module 1 ("calf health") consisted of four sets of lecture slides covering the same material the CB group received. The students received access to the lecture slides on Monday via an online learning management system. On Friday, students received 75 min of lecture by the same course instructor and were able to ask questions at any time.

Module 2 ("lameness") focused on lameness in adult dairy cows. The learning objectives in module 2 targeted the following cognitive learning levels: remembering, understanding, and evaluating (Krathwohl, 2002); learning objectives were the same for LB and CB. Case-based teaching materials were given on a Monday and consisted of a "student materials" document containing information in the form of written paragraphs providing students with the definition of lameness, risk factors to lameness, identification of lameness, treatment of lameness, management strategies for lameness, links to online reading materials relative to lameness, and the lameness case study. Students in CB were instructed to read the "student materials" and review the lameness case study prior to the lab section on Friday. The lameness case study included a descriptive scenario asking students to evaluate management factors associated with lameness (e.g., flooring, injury, handling, and nutrition). The lameness case study included questions that were designed so that students had to actively seek out information (Anderson and Krathwohl, 2001) from the "student materials" to evaluate the management factors described in the scenario and their potential effect on lameness. During the 75-mi lab section, a course instructor guided the CB students through the questions in the lameness case study, and students were able to converse with peers and the instructor while answering the lameness case study questions. The materials for the LB group in module 2 ("lameness") consisted of four sets of lecture slides covering the same material the CB group received. The students received access to the lecture slides on Monday via an online learning management system. On Friday, students received 75 min of lecture by the same course instructor and were able to ask questions at any time.

To assess performance, students were asked to take both pre- and post-quizzes (maximum score of 10 points possible) for each module which included a 10-question multiple-choice quiz to assess content knowledge and 3 short-answer questions to assess critical thinking. Students completed the pre-quiz at the beginning of the week before any module content was made available to them. Students completed the post-quiz at the end of the week after module content was presented by a course instructor during lab. The pre- and post-quizzes for the CB and LB groups were identical and administered through the online management system. A course instructor graded all students' assignments with the same rubric; student names were anonymized to avoid bias when grading.

Students were asked to complete an attitude assessment after completing each module. The attitude assessment included eight Likert-scale questions with possible responses of "Strongly Agree," "Agree," "Disagree," or "Strongly Disagree." Two free-response questions were also included in the attitude assessment to allow students to freely share their opinions.

Statistical Analysis

Three separate mixed linear regression (PROC MIXED) in SAS v 9.4 (SAS Institute Inc., Cary, NC) models were used to assess the effect of teaching method (CB or LB; predictor) on three different continuous outcomes for student performance: change in short-answer quiz score (post-short answer – pre-short answer), change in multiple-choice quiz score (post-multiple choice – pre-multiple choice), and change in total quiz scores ([post-short answer + post-multiple choice] – [pre-short answer + pre-multiple choice]). All models included student as a random effect and module ("calf health" or "lameness") as a fixed effect. The LSMEANS statement was used to obtain means ± SE. Whether or not a student attended lab in person ("lab attendance") was initially included in each model but was removed due to $P > 0.05$.

Student responses to the Likert-scale questions were collapsed to create "Agree" ("Strongly Agree" and "Agree") and "Disagree" ("Strongly Disagree" and "Disagree") for final analysis. The proportion of students who agreed or disagreed with each Likert-scale statement was calculated. A logistic regression (PROC GLIMMIX) in SAS v 9.4 (SAS Institute Inc., Cary, NC) was used to determine if the teaching method (CB or LB; predictor) affected the proportion of students who agreed with each Likert-scale statement (outcome: agree: yes/no). The logistic regression controlled for module ("calf health" and "lameness") and included student as a random effect.

Thematic analysis of the free-response section of the attitude assessment was conducted as described in Braun and Clarke (2006). Three members of the research team performed an initial evaluation of student free responses to identify recurrent ideas and develop emergent themes. The three initial coders each offered a unique perspective and experience level to the analysis. One coder was the instructor and has both qualitative and quantitative research experience. The second coder was a graduate student blinded to treatment with knowledge of study design. The third coder was an undergraduate student with no connection to the project or course, who provided a fresh, outside perspective. Two of these three members then independently coded student free responses for theme. The original interobserver agreement for thematic analysis was 92%. Interobserver agreement for the thematic analysis was calculated by dividing the number of codes that were coded the same by the two observers by the total number of codes completed. One hundred percent interobserver agreement was achieved through little discussion between the two observers.

RESULTS

One student did not submit the pre-quiz for either module, so their scores were excluded from quantitative analysis. Twenty-four students were included in the final quantitative analysis, and 25 students were included in the final qualitative and thematic analysis. The raw mean scores of each assignment are presented in Table 1. Means of the change in post- and pre-quiz scores are presented in Table 2.

Table 1. Raw scores (mean ± SD) on course assessments, by module and teaching method (n = 24 students)

Module	Assessment type	CB teaching method	LB teaching method
Calf health	Pre-quiz	5.65 (±1.04)	6.23 (±1.68)
	Post-quiz	7.73 (±1.19)	7.72 (±1.43)
	Pre-short answer	2.91 (±1.1)	2.42 (±0.82)
	Post-short answer	3.32 (±0.99)	3.46 (±0.85)
Lameness	Pre-quiz	7.92 (±1.55)	8.55 (±1.13)
	Post-quiz	9.23 (±0.93)	8.45 (±0.93)
	Pre-short answer	3.10 (±1.23)	2.88 (±1.31)
	Post-short answer	3.75 (±1.17)	3.91 (±0.99)

Table 2. Least-squares means (±SE) for change in quiz score between CB and LB teaching methods, after controlling for module (n = 24 students)

Assessment	CB teaching methods	LB teaching methods	P-value
Change in multiple-choice quiz score	1.7 ± 0.32	0.8 ± 0.33	0.06
Change in short-answer quiz score	0.02 ± 0.4	0.6 ± 0.4	0.1
Change in total quiz score	1.5 ± 0.6	1.2 ± 0.6	0.5

Table 3. Difference in proportions of students (n = 25) who agreed with each survey statement between CB teaching and LB teaching methods (%, (n/n))

Survey statement	Agree CB teaching	Agree LB teaching	P-value
I felt I learned a lot during this module.	84% (21/25)	96% (24/25)	0.17
I enjoyed the teaching method used in this module.	76% (19/25)	100% (25/25)	0.03
The amount of time I spent on this module was reasonable.	96% (24/25)	88% (22/25)	0.74
I felt the assignments were too demanding.	24% (6/25)	35% (9/25)	0.69
I felt the assignments improved my critical thinking skills.	80% (20/25)	80% (20/25)	1
I felt the assignments improved my problem-solving skills.	80% (20/25)	64% (16/25)	0.19
I felt this module was applicable to the real world and provided practical application of the material.	96% (24/25)	92% (23/25)	0.60
I wish this teaching method was utilized in more of my classes.	60% (15/25)	88% (22/25)	0.04

Student Performance on Quizzes

There was no difference (mean ± SE) between CB and LB for the change in short-answer quiz scores (0.02 ± 0.4 vs. 0.6 ± 0.4; P = 0.1), the change in multiple-choice quiz scores (1.7 ± 0.32 vs. 0.8 ± 0.33; P = 0.06), or the change in total quiz scores (1.5 ± 0.6 vs. 1.2 ± 0.6, respectively; P = 0.5).

Attitude Assessments

For the statement "I enjoyed the teaching method used in this module," 68% (17/25) of CB students agreed, compared with 96% (24/25; Table 3) of LB students (P = 0.03). For the statement "I wish this teaching method was utilized in more of my classes," 60% (15/25) of CB students agreed, compared with 88% (22/25) of LB students (P = 0.04; Table 3). The proportion of students who agreed for the remaining six Likert-scale statements was not different between CB and LB (P > 0.17; Table 3).

Themes from Attitude Assessment Free-Response

Five themes emerged from the analysis: preference, COVID-19, perceived drawbacks, perceived benefits, and awareness of available course materials. Eighteen total subthemes emerged from the main themes (Table 4). The proportion of times each theme was mentioned by students in CB and LB is presented in Table 5. All student responses included in this manuscript are direct quotes and have not been altered. For example, a student stated "I like the lecture but I also like the case studies. I like learning about it and then applying it to a real-life situation. It just helps me put it all together and apply it.," which was coded as both preference and perceived benefits. The phrase "I like learning about it and then applying it to a real-life situation" conveys the recurring theme of preference for the order in which the course material is presented. The phrase "It just helps me put it all together and apply it" conveys the recurring theme of perceived benefits of the teaching method utilized.

The theme preference included responses that indicated a preference for teaching method or teaching practices. Preference emerged in 80% (Table 5) of CB comments and 84% (Table 5) of LB comments. Student responses included a range of preferences including preferring lecture, the order the material is presented by method, and a clear indication of dislike. Within the theme of preference, a subtheme of "order

Table 4. Themes and subthemes from thematic analysis of survey attitude assessment free-response answers (n = 25 students)

Theme	Subthemes
Preference	Combination of teaching methods, sequence of teaching methods, hands-on, professor interaction, organization, consistency, and discussion among peers
Perceived benefits	Applicable to real life, hands-on application for future, critical thinking, self-paced, and retention
Perceived drawbacks	Oversimplified, workload, accessing materials was confusing
COVID-19	In-person, virtual learning challenges
Awareness of available materials	Impossible to access and utilize materials

Table 5. Proportion of times theme was mentioned by students (n = 25) in the thematic analysis of survey attitude assessment free-response answers

Theme	Proportion of times mentioned CB (%)	Proportion of times mentioned LB (%)
Preference	80	84
Perceived benefits	44	40
Perceived drawbacks	28	18
COVID-19	12	18
Awareness of available materials	0	0.2
Other	0.2	0.4

of teaching methods" arose from students directly stating that they prefer to first have information directly explained to them in a lecture before being exposed to a case study that requires them to work through real-life scenarios. Preference for order of teaching methods was also observed in our students who explained that they believe they learn best by having new concepts explained to them directly instead of navigating new content on their own. The subtheme order of teaching methods revealed a consensus that students in our study preferred to be introduced to new material via an instructor-guided lecture rather than CB teaching methods.

Additionally, within the theme of preference, a subtheme of "single teaching method" emerged from students' comments stating preference for either CB or LB teaching methods or a preference for consistency of teaching method. Some students in our study stated that they did not prefer a specific teaching method in a classroom but rather prefer that instructors are consistent with the teaching method used. Several students in our study stated that case studies should not be the sole, or primary, teaching method used but instead a supplement to LB teaching. The majority of students in our study preferred lecture as the primary teaching method justified by the structure associated with lecture. The subtheme of a "single teaching method" is informative that not all students appreciate/enjoy the same teaching methods; in fact, some students feel very strongly one way or another as seen in the comments. Within the theme of preference, we also observed students' preference for utilizing a mixture of teaching methods that would include more interactive discussion and less memorization-based assignments.

The theme of perceived drawbacks included responses that discussed a perceived drawback of the teaching method utilized in the module. Perceived drawbacks were more frequently discussed in regard to CB teaching (28%; Table 5) compared with LB teaching (18%; Table 5). Students in our study disliked the independent nature of CB teaching for fear of confusion and misinformation when not guided through new material by an instructor. Case-based students also discussed being overwhelmed by the amount of reading and time associated with CB teaching in this study. Some students expressed dislike of the redundant nature of lectures and lack of hands-on activities in LB teaching in this study.

The perceived benefits theme included responses that discussed students' perceived benefits of the teaching method utilized in the module. Perceived benefits were more frequently discussed in regard to CB teaching (44%; Table 5) than LB teaching (40%; Table 5). Many students discussed critical thinking, real-life application, and deeper understanding as benefits of CB learning. Within perceived benefits, a subtheme of "real-life application" emerged from several CB students who stated that CB teaching allowed them to easily apply knowledge to real-life scenarios. A few students stated that they believed they learned better using CB teaching methods than LB because applying knowledge acquired in the learning process to a real-life scenario (case study) helped them better understand the material than listening to a lecture and taking an exam. Some students did enjoy the deeper understanding of course material attributed to the independent nature of CB teaching. Many students appreciated the following components of lecture in our study: the ability to rewatch lectures in an online environment at their own pace alongside provided, outlined lecture notes that guide them through the course material. Notably, students appreciated the guiding role of an instructor in the learning process for clear communication of new material.

The awareness of available materials theme included responses that indicated unawareness of course materials. This theme emerged mostly in the LB group from student comments expressing a difficulty in finding course materials on the online learning management system. These students expressed a feeling of frustration in the amount of time spent locating course materials that discouraged them from engaging with materials the longer they spent locating them.

The theme of COVID-19 included student responses that discussed learning challenges associated with COVID-19. Students demonstrated an understanding of the challenges of the pandemic (e.g., online learning, limited face-to-face interactions) and expressed a preference for face-to-face interaction and an understanding attitude toward the accommodations their instructor(s) and university had to make.

DISCUSSION

The objectives of the present study were to assess the effects of CB compared with LB teaching methods on student performance and attitudes in an animal science course in higher education. Though we did not observe a significant change in assessment scores between CB and LB groups, we obtained valuable feedback through the attitude assessment to inform future teaching practices in a similar environment, mainly

that students appreciate case studies but want to receive the information via lecture first and students value interaction with their peers and instructor(s).

Student Performance

The results of the present study do not indicate a difference in student performance between CB or LB teaching methods and, therefore, do not provide support for or against either method. Interestingly, we did observe a tendency for CB teaching methods to improve student performance on multiple-choice questions. The observed tendency may be explained by the findings from Panja et al. (2013) and Bi et al. (2019), whereby CB teaching methods improved student performance on CB and non-CB assessments. Case-based teaching methods have been associated with a deeper understanding and higher-level learning of the content compared with LB teaching (Panja et al., 2013; Bi et al., 2019). In a meta-analysis, Bredow et al. (2021) reported a consistent finding in existing research that student performance improved when active learning (e.g., CB) was used in addition to lecture. Future research in higher education in animal sciences should evaluate both student performance and attitudes when CB teaching methods are used as an adjunctive method to lecture. This approach is supported by our results from the thematic analysis that indicated students appreciate case studies after receiving course content via lecture. The theme of perceived benefits, in which students explained that the independent nature of CB teaching led to a greater understanding of content, may help explain the tendency for CB teaching methods to improve student performance on multiple-choice questions in our study. Both Panja et al. (2013) and Bi et al. (2019) had larger sample sizes compared with our study and took place over consecutive years rather than two week-long modules as in our study. Observing results such as in the study of Bi et al. (2019) and Panja et al. (2013) may be possible if we repeated our study with a larger sample size over a longer period of time and were not limited by COVID-19 restrictions (i.e., all students could be in person for instruction). Student performance also may not have been significantly different between CB and LB groups in the current study because the quizzes were given immediately after receiving the information, so the recall of information happened over a short period of time (i.e., a few days vs. a few weeks; Panja et al., 2013 and Bi et al., 2019). Undergraduates in a biochemistry course exposed to CB teaching performed better at the beginning and the end of the semester than their classmates not exposed to CB teaching (Kulak et al., 2017). Kulak et al. (2017) suggest that CB teaching may result in better student performance, and greater knowledge retention, over longer periods than non-CB teaching methods. To better assess the long-lasting impact of CB on student performance in animal sciences, future studies should focus on assessing the effect of CB teaching methods on long-term knowledge retention.

Student Preference

Seventy-six percent of students in our CB group "enjoyed the teaching method used in this module" compared with 100% of LB students. Students' enjoyment of LB teaching methods in our study suggests that students may prefer LB over CB. Sixty percent of students in our CB group "wish this teaching method was utilized in more of my classes" compared with 88% of LB students. These results are, in part, explained by the theme of preference derived from the free responses on the attitude assessment. Preference, specifically the subtheme "order of teaching methods' revealed that students in our study enjoyed having new information delivered to them in an instructor-guided lecture before engaging in CB teaching methods.

Students' preference for LB teaching methods in our study contrasts existing literature in which students reported a higher satisfaction with CB methods than LB methods (Panja et al., 2013; Bi et al., 2019). However, the groups exposed to case studies in Panja et al. (2013) and Bi et al. (2019) both participated in smaller group discussions that were not offered in our study. Additionally, Boström and Hallin (2013) reported that approximately half of teaching and nursing students in their study preferred working with peers. However, the students in our study were limited in their ability to interact with one another while learning the material due to COVID-19 social distancing requirements. The theme of perceived benefits revealed that students in our study desire peer discussion in the learning process, and, therefore, student satisfaction of CB methods could be increased through including small, peer discussion groups. Students in our study did have the chance to interact with a course instructor and peers in the optional in-person lab section at the end of the week, but the expectation at this point was that students had already reviewed and learned the module content. Future studies should assess the effect of peer-to-peer interaction on the efficacy of CB teaching methods.

The attitude assessment provided insights into reasons students did or did not enjoy CB teaching in the present study. Student reasoning for the enjoyment of CB teaching methods was extracted from the thematic analysis in the theme perceived benefits and included self-paced, deeper thinking, and interaction with peers and instructor(s) (Table 4). In contrast, student reasoning for not enjoying CB teaching methods was extracted from the thematic analysis in the theme perceived drawbacks and included self-taught and heavy workload, and did not align with personal learning style (Table 4). The themes perceived benefits and perceived drawbacks explain student preferences for teaching methods observed in the theme of preference. From the thematic analysis, we inferred that the perceived benefits and perceived drawbacks of CB teaching methods indicate students may prefer to receive information first via LB teaching methods, followed by a case study to apply the information presented in the lecture. Our results are similar to Boström and Hallin (2013) who reported three of four nursing and teaching students desired clear instruction in the classroom before beginning a task. Likewise, Gal et al. (2018) reported students feel that the professor is an integral part of the learning process. Like Gal et al. (2018), our theme of perceived benefits suggests that students appreciate the guiding role of a professor in LB teaching and may not want to eliminate the professor from the initial instruction process. Instructors interested in integrating CB methods into courses should consider providing some material via lecture, followed by case studies in which students get to interact with their peers and the instructor.

Eighty percent of CB students in our study agreed "the assignments improved my problem-solving skills" compared with 64% of LB students, but there was no difference between our CB and LB groups' agreement with the statement "I felt the assignments improved my critical thinking skills." Similarly, Bi et al. (2019) and Mesthrige et al. (2020) found that students perceive CB teaching methods to be beneficial in

improving their problem-solving skills. Our theme perceived benefits provides support for similar conclusions to Bi et al. (2019) and Mesthrige et al. (2020) as students in our study expressed that they valued how CB teaching improved their understanding and memory of material which allowed them to better apply their acquired knowledge to the case study presented.

Based on the attitude assessment results, time and workload were not students' primary concern with the teaching methods (Table 3). Almost all students in CB and LB (96% vs. 100%) agreed "the time I spent on this module was reasonable" (Table 3), which agrees with findings in Gal et al. (2018) of the first-year medical students who thought the workload associated with active learning was reasonable. In contrast, Gal et al. (2018) also reported that the second-year medical students in the study perceived the workload associated with active learning as too demanding because the students felt that they had to work on their own as opposed to in a collaborative effort with their peers. Despite 96% of CB students in the present study agreeing with the Likert-scale statement, "the amount of time I spent on this module was reasonable," we received responses indicating negative concerns about the workload associated with CB teaching methods such as time to complete task, associated point value with task, and difficulty navigating content, which were captured in the themes perceived drawbacks and awareness of available materials, respectively.

Lastly, a unique characteristic of our study population is that our study consisted of the third- and fourth-year undergraduates and the first-year graduate students in animal sciences who may not have been previously exposed to CB teaching. Gal et al. (2018) evaluated the differences in student preference for active learning methods in the first- and second-year medical students and found a temporal bias. The first-year students in Gal et al. (2018) had a more positive rating of participatory methodologies (e.g., CB teaching, case studies, and group discussion) compared with the second-year students, suggesting that results in the present study could be influenced by the inclusion of students who were in the later years of their academic career. The medical field utilizes case studies to prepare students to problem-solve when presented with a patient in the field (Gal et al., 2018), much like animal science students may need to problem-solve when presented with a problem in the field (Wattiaux, 2009). Future research should evaluate the effect of previous exposure to CB teaching methods on student performance and attitude toward CB teaching methods compared with LB teaching methods.

Strengths and Limitations

Our study took place amidst the COVID-19 pandemic during which students were quickly forced to transition to an online or hybrid (partially online and partially in person) format that added a layer of complexity to their classroom experience and, in some cases, limited student access to their usual, in-person learning. Students in the present study may have faced challenges outside of the classroom, including unemployment, loss of social contact, poor internet connection, and access to technology and materials (Aristovnik et al., 2020), that may have influenced their performance in our study. Students in the present study acknowledged challenges associated with learning during COVID-19 such as the lack of face-to-face instruction, the lack of peer interaction through discussion-based assignments, and difficulty engaging with the material through online lecture videos. Future instructors in similar conditions as described in our study (i.e., online or hybrid environment) should consider incorporating pedagogical practices that satisfy student desire for live interaction between the students and instructor(s) to compensate for the lack of face-to-face class meetings.

Additionally, our sample size was relatively small because our study population was dependent on the students who enrolled in the senior-level dairy management course in the semester the study took place, and, as such, we did not recruit participants from outside the course. A larger sample size could have potentially resulted in a statistically significant change in students' performance between CB and LB teaching methods. Future studies should consider larger sample sizes, which could be achieved by including multiple animal science courses and conducting the study over multiple semesters.

CONCLUSIONS

The effect of CB and LB teaching methods on student performance was not different in the present study, but student insight received through the attitude assessment provided valuable information that can inform instruction methods in animal sciences in higher education. Overall, students in our study did appreciate CB teaching methods for the discussion and problem-solving aspects but preferred to be presented with the course content in the form of a lecture before engaging in a case study. Students indicated that they appreciate the guidance of an instructor through classroom materials and like to be challenged to apply the knowledge acquired in the classroom to real-life scenarios (e.g., case studies). The COVID-19 pandemic added a unique element to our study and should be considered for its influence on student performance, equity, and well-being. Student comments from our study suggest prioritizing the connection between classroom and real-life application, which can be achieved through introductory lectures and subsequent case studies.

Conflict of Interest Statement

The authors declare no conflict of interest.

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