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Team-based learning in a subsection of a veterinary course as compared to standard lectures

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Abstract : Team-Based Learning (TBL) maximizes class time for student practice in complex problems using peer learning in an instructor-guided format. Generally entire courses are structured using the comprehensive guidelines of TBL. We used TBL in a subsection of a veterinary course to determine if it remained effective in this format. One section of the class was taught the material using PowerPoint based lectures. The other group was taught the same material by the same instructor using TBL. All students took the same examination on the material at the end of the course and again 18 months later. There were no differences in the course examination or course grades but grade distributions differed; TBL grades were more widely distributed and female TBL students outperformed male TBL students. TBL students scored significantly higher on the repeat examination. Objective student engagement was high and students were positive about the experience.

Keywords: veterinary education, urinary surgery, knowledge retention, course design, active learning, adult education

I. Introduction.

Team-Based Learning (TBL) is a constructivist course format designed to shift the focus of classroom time from instructor-led lectures and discussions to interactive small group sessions captained by students, all without decreasing class sizes, increasing instructor numbers or increasing class time (Michaelsen & Sweet, 2008a). With TBL, students review material prior to class in order to be prepared for deeper discussions and active learning during class. Units generally start with short tests (readiness assessment tests or RATs) covering basic material from the assigned readings. Students take the tests individually (IRAT) and then as a group (GRAT) and get immediate feedback on their responses. Misconceptions and errors are clarified with a short lecture. During the remaining sessions for the unit, students work with their teammates in carefully balanced groups of 6-7 members on complex real-world problems that require higher level thinking skills. The application exercises are designed to follow the "4S" guidelines: centered on a problem of *significance* to the students, all groups should be working on the *same* problem, students must make a *specific* choice, and groups should report their choices *simultaneously* (Michaelsen & Sweet, 2008b). The instructor guides the process to ensure the important components are "discovered" and applied appropriately. Students are held responsible for the preclass work with in-class assessments and via peer feedback and reviews (Sweet & Pelton-Sweet, 2008). Repeating the knowledge acquisition and application cycle through the readiness assessment tests and complex problems generally leads to increased understanding and retention (Pileggi & O'Neill, 2008; Goldberg & Dintzis, 2007), while group discussions encourage the development of teamwork, better communication and enhanced problem solving as well as engaging the learners and creating an active learning environment (Haidet, O'Malley, & Richards, 2002; Giuliodori, Lujan, & DiCarlo, 2006; Pickrell, Boyer,

Oehme, Clegg, & Sells, 2002). This format also means the instructor is available to assist with the more difficult problem solving and application skills rather than being involved primarily with the initial dissemination of knowledge. Unlike problem-based learning (PBL), the instructor creates problems and activities that guide the learning process rather than allowing students to determine their learning path. One instructor can manage a large number of students, as compared to PBL which relies on a facilitator for each group. Finally, TBL is more readily adapted to all levels of learning, including the clinical setting (Davis & Harden, 1999).

While group work, case-based discussions and PBL have been used and evaluated in veterinary curriculums, TBL has not been commonly used in veterinary colleges and we could find no peer-reviewed articles on the subject. TBL is widely used across many disciplines, including other health sciences, but is usually applied to an entire course (Michaelsen & Sweet, 2008b). In the veterinary curriculum at the University of Minnesota (UMN), many courses are taught by multiple instructors. The curriculum is very full and students have limited time to reflect on their learning. We were interested in finding a way to convert the ever expanding course material into a format that encouraged more active and deeper learning while not increasing student workload. Switching class sessions to TBL carried the potential for better understanding of the material due to more meaningful and thorough discussions with the instructor and with peers, more enjoyable class time, and better long term retention through application practice without altering the student: teacher ratio or increasing the time students spent on the material. TBL had not previously been used in our curriculum and coordinating efforts across multiple instructors with a new teaching modality could be highly time-consuming and possibly ineffective (Thompson, Schneider, Haidet, Perkowski, & Richards, 2007).

The UMN Urinary Systems Disorders course (CVM 6460) is taught as an introductory course to all second year veterinary students. The large animal subsection of CVM 6460 has been taught by one of the authors (EM) for several years. Historically, the classes were taught using the standard lecture/PowerPoint format, with many attempts made during class to make the discussions interactive using case examples and in-class questions. However, based upon student knowledge exhibited during clinical rotations, retention and understanding remained suboptimal with students who were taught using this format.

Our goal was to evaluate the use of TBL in a large animal urinary surgery as taught in a subsection of a urinary systems course. Our hypothesis was that TBL could be utilized in a subsection of a veterinary medicine course with equivalent or better test results and student and instructor satisfaction as compared to standard lectures. Furthermore, we anticipated TBL would lead to better long term retention of the material.

A. Course Description.

The Urinary Systems Disorders course is a required course. The large animal surgery portion of the course has routinely comprised three lectures of 50 minutes each. We chose this subsection to trial TBL due to the limited risk it posed to the students and interest of the instructor. Since the class is meant to serve as an introduction, the topics would be reintroduced further along in their education. If the TBL format failed to provide adequate learning, we could remedy deficiencies later. Also, this group of students was involved in a student leadership course that included discussion and practice of effective group interactions, including appreciating different strengths and styles, problem solving as a team, and giving peer feedback (Root Kustritz & Nault, 2010). We hoped this would counter the limited time available for group dynamics as

TBL generally utilizes peer feedback to improve member responsibility and group function but opportunities to adjust would be limited in a single session.

Institutional review board approval was obtained to alter the course during the spring of 2010. The CVM curriculum committee approved offering the subsection of the course twice during the semester to allow controlled evaluation. The course was required for all 92 students in the second year of the curriculum.

II. Methods.

A. Study Population.

Second year veterinary students were randomly divided based upon student identification numbers. One section of the class served as the control group, attending the standard set of three PowerPoint based lectures. The other students in the class were presented with the same material in a TBL environment. Each group of students was instructed not to attend the alternate class sections

B. Course administration.

Students in the TBL group attended a brief meeting to explain the process, the research questions, and obtain informed consent.. After explanation of TBL, portions of TBL were demonstrated during this session including diverse group formation, the concept of the individual (IRAT) and group (GRAT) readiness assessments, use of a classroom response system (i>Clickers), and advanced team based problem solving. The mock IRAT also served as a preclass survey to assess student study habits, use of social media during class, and frequency of group work. The explanation was performed individually for the few students unable to attend the introductory session.

A course website was developed on which *all* the students were able to access class objectives, lecture PowerPoints, class notes, study questions, and extra reading materials. The site also contained a single forum to allow students from either section to post questions about the material or about the course expectations. Students in the TBL portion of the course were asked to spend 1.5-2 hours reviewing the material prior to attending class and in lieu of a similar amount of class time. Students in the control group were also granted access to this material but were not required to use it.

C. TBL Session.

A single, separate class period was reserved for the TBL session. Groups of 6-7 students were formed transparently at the start of class to maximize group diversity (based upon interest in surgery, experience in large animal veterinary medicine, advanced degrees, and other factors). Each group was given a packet of material containing the IRAT questions in written form along with group member evaluation forms.

The 90 minute class started with students taking the IRAT on paper, followed by clicker responses to record answers. Groups then convened to discuss the questions and take the GRAT in a similar fashion. After the first student completed the IRAT, a two minute warning was called. Most students required 10-12 minutes for a 10 question IRAT, with only 5 minutes

needed for the corresponding GRAT. Upon completion, the instructor led the class in a discussion of the answers to the IRAT/GRAT questions.

Students were then presented with case studies in which they were required to reason through diagnosis and appropriate action, using their knowledge of the material and with small group discussion. The instructor was on hand to assist with questions. Following TBL "4S" guidelines, groups responded simultaneously with specific choice answers. Subsequently, the instructor led a class discussion of each of the cases, allowing the students to give explanations for their choices, while also giving input and suggestions. Two cases were covered in the remaining time period.

An additional 15 minutes were spent performing evaluations of group members and of the TBL format. For the peer evaluations, each student was given a total of 10 points multiplied by the number of other group members (not including themselves) to distribute (Davidson variation of the Michaelsen method; Levine, 2008).

D. Examinations.

At the end of the CVM 6460 course, students from both the control and TBL groups were given the same exam including 15 large animal urinary surgery questions (Appendix 1). Large animal urinary surgery questions were generally case related, application type problems and were pulled from a study guide that was given to both sections. Due to variations in class discussions, a deliberate attempt was made to ensure the questions were evenly distributed so that any question that reflected a topic more heavily emphasized in one section was balanced by a question that was better emphasized in the opposite section. Over half of the questions were either equally emphasized in both sections or were not emphasized in either section. Grades were assigned on a standard scale with >90% resulting in an A and <60% resulting in an F.

All students were asked to repeat the same 15 question examination during the first half of their 4th (final) year of veterinary school. Students were asked to repeat the examination without reviewing the material and without using any resources (online or print). Students further identified whether they were in the TBL or non-TBL groups, were pursuing training in large animal species, and which large animal rotations they had experienced at the time of the repeat examination. Participation was anonymous and voluntary.

E. Evaluation.

To ensure groups were similar, comparisons were made between TBL and control groups in terms of prior GPA and ultimate grades for the course using Student's t-tests. Time spent on the website was evaluated both to determine if TBL students were accessing the materials prior to class and to obtain a baseline of website use by control group students.. To determine if the class format affected performance, Pearson's chi square test was used to analyze test question accuracy and number of students both failing and excelling in the large animal urinary surgery subsection of the course. The impact of TBL group discussions was analyzed by comparing differences in IRAT and GRAT scores for group members. Calculations were performed to determine the correlation between IRAT/GRAT scores and examination scores. Student responses on pre- and post-course surveys and professor's response to the format (based upon notes taken throughout the process) were also collected. Finally, repeat examination scores were compared using Student's t-tests with individual questions analyzed by Pearson's chi square

test. TBL and non-TBL students retaking the examination were compared using Pearson's chi square test for large animal interest and with Student's t-tests for number of large animal rotations.

III. Results.

A. Group comparison.

Of the 92 students in the second year class, 50 students were randomly selected to participate in the TBL section and 38 participated (76%). The remaining 12 students joined the non-TBL group. No attempt was made to determine why students declined participation. In the TBL group, 26% of the students were male (n=10), while in the non-TBL group, 20% were male (n=11). No significant difference was present between groups in terms of cumulative GPA (TBL : 3.38 $\pm$ 0.46; non-TBL : 3.29 $\pm$ 0.43; p=0.3341).

B. Preclass work.

All but two of the TBL students were on the course website at least 30 minutes in advance of the TBL class session (36/38; 95%) while 17/55 (69%) of the control group students were on by the same time frame, despite already having one standard class session. Most TBL students reported they followed the guidelines and studied 1-2 hours prior to class (22/31 students completing the survey), with one studying less and seven studying more than two hours. The majority of the students only reviewed the lecture PowerPoint and notes (27/31; 87%). The question forum on the course website was rarely used and only to ask what to study, not for questions on the material. In the preclass survey of the same students, 97% reported they never or rarely reviewed material prior to class and 37.5% reported they sometimes use extra resources.

C. Exam performance.

No students failed the course and there were no statistically significant differences in overall course grades between groups (TBL: 36.8% A's; non-TBL: 44.4% A's). There were no significant differences in urinary surgery test scores between TBL and non-TBL students (TBL 22.6 $\pm$ 4.0; non-TBL 21.9 $\pm$ 3.4; total 30 points; p=0.3984). However, non-TBL students were more compactly distributed for urinary surgery test scores, with TBL students having more A's and more F's on the subsection test (Figure 1). This pattern was not seen in course grades and student performance on the urinary surgery portion of the test did not vary by class rank quartile (Figure 2). Additionally, while scores for males and females were similar for the non-TBL students (21.5 $\pm$ 3.5 men; 22.1 $\pm$ 3.5 women; p=0.5946), women in the TBL group significantly outperformed the men (20.0 $\pm$ 2.8 men; 23.4 $\pm$ 4.1 women; p=0.0116). There were no significant performance differences between groups by sex.

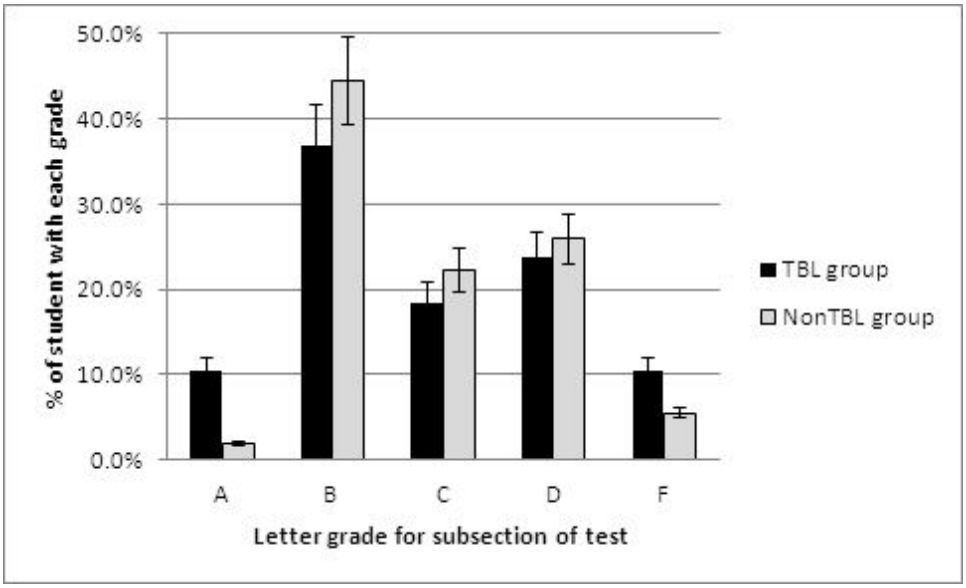

Figure 1. Performance on the large animal urinary surgery subsection of the test showing percent of class with grades of A, B, C, D or F. Chi square comparison between TBL (n= 38) and non-TBL groups (n=55): p=.0713; error bars depict standard deviation. The TBL students were overrepresented on both ends of the spectrum.

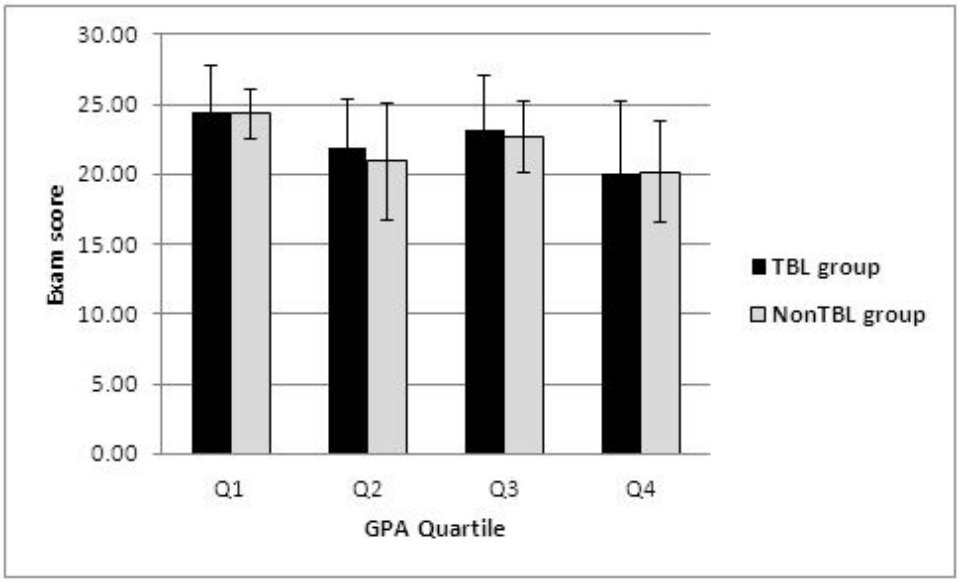

Figure 2. Exam scores by group and class rank quartile. Q1 = lowest, Q4= highest quartile; n=38 TBL, n=55 non-TBL. Exam scores are raw data (2 points per question, 100% =30 points); error bars depict standard deviation. No significant difference was seen by class quartile between groups.

D. Group performance.

Substantial improvement was noted between IRAT scores and GRAT scores for individuals (Figure 3). Improvement in scores was noted for 81.6% (31/38) students. Four students had identical scores and three had decreased scores (-1) on the GRAT compared to the IRAT. Two out of six groups had perfect scores on the GRAT (range 7-10) while no students had perfect scores on the IRAT (range 4-9). Two of the three students with lowered GRAT scores were in the same group; these students decreased scores from 8 points to 7 points. This group also had two students with the lowest IRAT scores (4 and 5). Twelve students improved their scores by 2 points (mode). However, the correlation between the IRAT score and the final exam score (34.9%) was better than that between the GRAT score and the final exam score (14.4%).

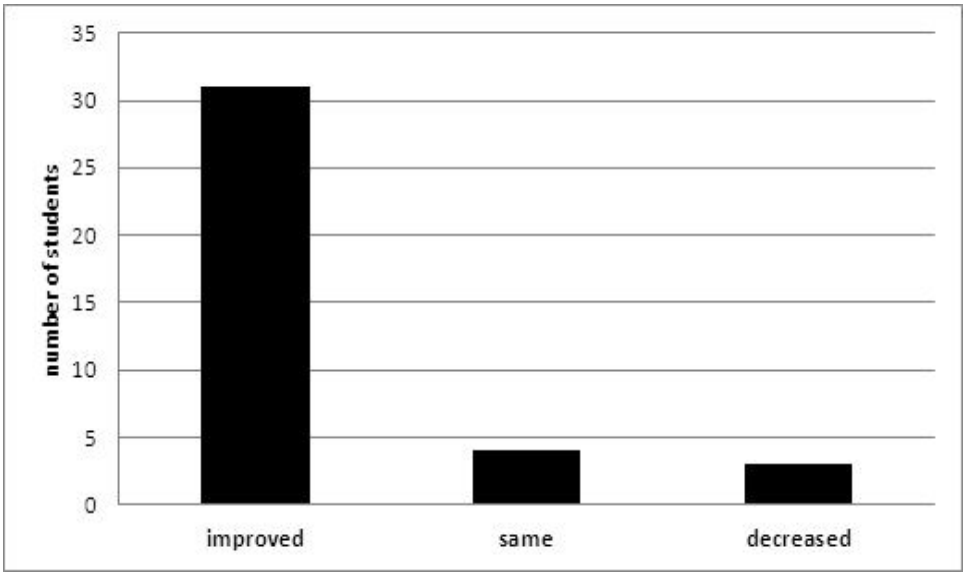

Figure 3. Change in scores between IRAT and GRAT by individual student. Total n=38. Improvement mode was 2/10 points. Three students had decreased scores; two of these students were in the same group.

As part of an associated study, we monitored group function using a previously validated survey (unpublished data; Appendix 2). The results of that work showed the biggest disparity was between one of the two groups with perfect GRAT scores and the group with the lowest GRAT scores. Many groups used consensus to reach an answer for the GRAT instead of majority votes.

E. Course evaluations.

No significant difference was noted between course evaluation scores from the previous year. Instructor evaluation scores were the same or higher than the previous two years. Due to the anonymous collection method, evaluation responses could not be stratified by TBL group. However, students included favorable comments about the new teaching methodology in midcourse and end of course evaluations.

The post-course survey solicited opinions on the level of learning and the TBL design (Appendix 3). Results showed students were generally cognizant of their level of knowledge (6/31 remarked they were surprised by their level of knowledge) and were comfortably challenged by the in class material (25/31; 81%). Six students reported being overwhelmed by the class material. Only one student felt it was not easy to ask questions about the material in class, five thought it was not very easy but was doable, and 26 felt it was easy to ask questions. In terms of applicable knowledge, 17/31 (55%) felt they could readily apply their knowledge to a case and an additional 11 thought they probably could but were not as confident.

Regarding team function, 27 students reported it was very easy to express their opinions within their team and the other four reporting it was somewhat easy. A large majority (28/31; 90%) felt their team accomplished a lot in terms of better understanding the material and no one reported that they became more confused after team discussions. When asked about the TBL format, 20 of the 31 that responded reported they definitely liked the format with an additional 10 reporting it was okay. One student would rather have had a different format. In the preclass survey given to the students during the informed consent meeting, one student reported regularly working with someone else and 25/32 (78%) said they sometimes study with others.

Prior to class, the TBL students admitted to significant off task work during class, with 41% using social media at least once during most classes, 31% frequently using social media during class, and 28% always accessing social media during class. Only 5/32 (16%) reported never using social media during class. During TBL, 24/31 (78%) reported using no social media during class.

Significantly more instructor time was required to perform administrative tasks required for TBL than for the standard course section, particularly as minimal work was required for the standard section of the course (updating of notes and PowerPoints only). This included setting up written and PowerPoint versions of the IRAT/GRAT questions, development of more advanced problems, developing peer evaluations, ensuring registration of clickers, and reassuring students of appropriate class times and responsibilities. Students frequently asked to verify the date of the classes and which class they were to attend. Instructor engagement and satisfaction with the actual class sessions was high for both groups; the higher student engagement in the TBL session was noticeable and rewarding.

F. Retention analysis.

Thirty-nine students participated in the repeat examination, 19 from the TBL group and 20 from the non-TBL group. Students in the TBL group significantly outperformed students in the non-TBL group (18.4 ± 4.0 vs 15.4 ± 4.6; total 30 points; $p= 0.0305$). This equated to a drop of 18.6% from the initial examination scores for the TBL group and a drop of 29.7% for the non-TBL group (Figure 4). Significantly higher scores for TBL students were noted for 3 questions, two of which reflected the topics covered during in-class case studies. No differences were noted between groups in terms of large animal interest or number of large animal rotations experienced.

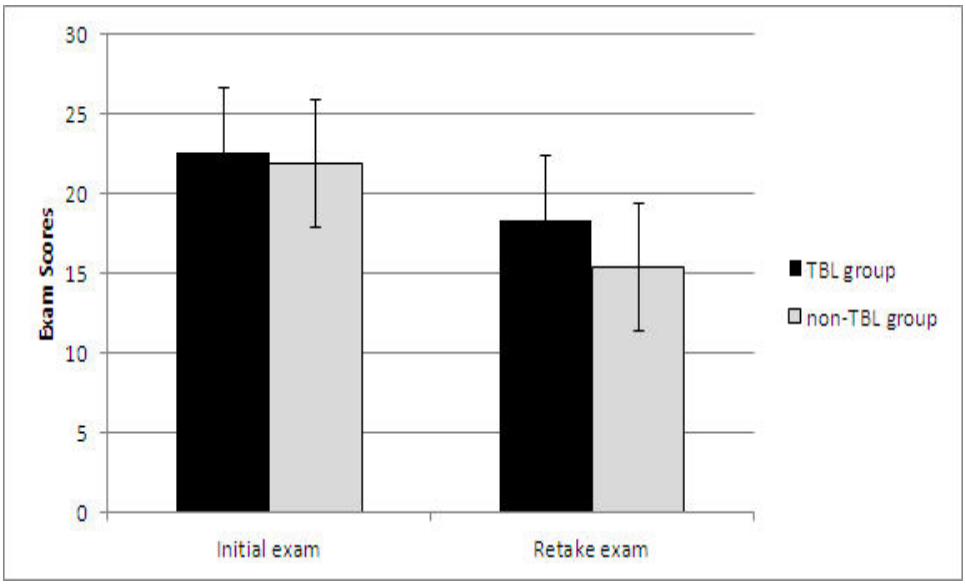

Figure 4. Comparison of scores between the course examination and the same examination taken 18 months later. Error bars denote standard deviation. No significant differences were noted between groups on the initial examination (p=0.3984; n=38 TBL, 55 non-TBL). However, scores for both groups significantly decreased over time (p values $\leq$ 0.002) and the scores for the non-TBL group were significantly lower on the repeat examination than for the TBL group (p=0.0305; n=19 TBL, 20 non-TBL).

IV. Discussion.

We were able use TBL successfully in a subsection of a veterinary course, with high levels of student and instructor satisfaction and with equivalent student test scores as compared to a control group taught by the same instructor. Knowledge retention appeared to be improved with the TBL format. We found similar strengths to TBL as others have: it allows highly interactive classes with large student numbers and with no increase in student work time and with at least similar student learning. The material that was standardly covered in three hours of lecture was covered in 1.5-2 hours of independent preclass work followed by 1.5 hours of in-class discussion. However, the amount of preparation time involved made it less appealing to convert already prepared instructional units of shorter duration.

After the TBL session (and before the exam), students reported feeling comfortable with the material and the majority thought they could apply it to an actual case. Overall test scores for the course were similar between groups. In contrast to other studies, we did not find either the lower performing or higher performing students did better with TBL (Letassy, Fugate, Medina, Stroup, & Britton, 2008; Koles, Stolfi, Borges, Nelson, & Parmelee, 2010; Wiener, Plass, & Marz, 2009). In fact, our TBL students tended to have a wider range of scores (higher and lower) regardless of class rank. The cause of this is unknown. Students may have felt more comfortable with the material and not reviewed as much for the test and/or students may not have learned the material as well that wasn't covered in the cases. Having more than one TBL session may enable students to estimate their level of self-directed learning more accurately. It is also possible that professional students may not follow this pattern as well as other groups, perhaps related to the higher level application-type problems. However, TBL is designed to be used in realistic,

complex situations and most TBL studies reflect this type of course design. Obviously test scores do not equate well to performance in clinics or in practice (Epstein & Hundert, 2002). Greater knowledge retention in the TBL group would suggest they may be better able to manage clinical cases related to the material, but it is impossible to assess true performance due to the high variability in student caseload exposure. Retention and usefulness is known to be enhanced if the learning context is similar to that required for use and with repeated test taking (Peile, 2006; Pyc & Rawson, 2010). The TBL format includes both and gives reason for optimism, particularly as students seemed to retain the material used most intensively in the classroom application exercises.

We found female TBL students outperformed male TBL students, but our overall numbers are small. Others have found no difference in small-group learning or even found females performing more poorly with TBL (Wiener, Plass, & Marz, 2009; Springer, Stanne, & Donovan, 1999). Comparing performances of men and women students in other professional programs is recommended to determine if sex differences truly exist.

Peer instruction and peer review is a key component of TBL and works to ensure students attend class and are prepared (Sweet & Pelton-Sweet, 2008). One of the disadvantages of using TBL in a subsection of a course is the lack of time for groups to mature (Sweet & Michaelsen, 2007**)**. As all first year veterinary students take a year-long course in leadership and teamwork, we hoped those skills would translate into this course. We saw improvements in student work similar to that expected with TBL, with over 81% of students improving from the IRAT scores, most students improving by two points or more (out of 10), and two groups obtaining perfect GRAT scores. Students commented that their understanding was enhanced by group discussions. However, the final exam scores more closely correlated with IRAT scores than with GRAT scores, suggesting exam performance was not strongly linked to group performance in our course. On the other hand, this pattern has been seen with other TBL studies (Letassy, Fugate, Medina, Stroup, & Britton, 2008; Nieder, Parmelee, Stolfi, & Hudes, 2005). One team was obviously struggling with group function and their GRAT scores reflected this; we would hope that this group would have improved over time with more opportunities for practice and feedback.

Students reported higher engagement and less off-task work; groups were able to handle more challenging questions, and peer instruction was effective in answering many of the questions. Even more exciting was providing time for students to think and problem-solve without adding curricular hours or extra work. The format also allowed the instructor to spend limited class time on the more challenging topics as identified by responses to the IRAT and GRATs.

As reported previously for TBL, the instructor found the TBL session to be added work but more enjoyable than the standard classes. Since lecture time is short and related to student performance on the RATs, there is minimal set up for class discussions. Class sessions do require a small amount of set up to organize RAT grading and group materials. Grading is readily facilitated by classroom response systems or IF-ATs (Immediate Feedback Technique forms; Epstein Educational Enterprises, Cincinnati, Ohio). However, TBL requires careful design of RATs and complex problems. Instructors must think carefully about the desired course outcomes to work backwards to develop related course activities. This requires substantial advanced planning and cannot be successfully accomplished at the last minute.

As an added benefit, we found veterinary students open to the idea of being involved in new teaching methodologies and commented positively on the midcourse and end of course

evaluations. Many more students agreed to be in the study section than was anticipated. Students that committed to the TBL session were obviously nervous about their roles; however, all but two did the preclass work on the course website and all but one attended the class session. This was much different from their self-reported study habits. One major challenge was estimating how much material the students could cover on their own prior to class. The course website included links to many related articles that were not used. In retrospect, students did tend to review both the notes and the PowerPoint prior to the class, and this would likely take at least as long as covering the PowerPoint during lecture sessions. On the other hand, the notes did contain material that was not discussed in the standard lecture format and could have been formatted so that students could better see the high points and read those areas only if interested. The main questions students asked were related to what they should study. This is in congruence with other reports suggesting structure is necessary for proper learning, and providing this structure in terms of objectives or study questions is useful for independent learning (Sibley & Parmelee, 2008).

Limitations to this study include both small numbers and potential bias due to instruction by the investigator. Repeating the study over multiple classes would be recommended but impractical. Due to curriculum changes, repeating the study on the same course material is no longer possible. We believe the smaller numbers in our study are offset by the controlled study design that enabled us to evaluate learners within a single cohort. Investigator taught studies have been shown to be biased toward more significant findings (Springer, Stanne, & Donovan, 1999). It is possible we biased the control group in a negative direction; however, the classes have been taught in a similar manner for many years, and all attempts were made to minimize changes for this class. It was more difficult to avoid introducing a positive bias to the control group due to the need to focus learning objectives for the TBL classes; this focus carried over in the instruction for both groups. TBL exposure has been found to improve student performance overall (Wiener, Plass, & Marz, 2009). However, our section was included in the final test of the course and the TBL section was scheduled for the very end of the semester, minimizing the likelihood of any secondary effects. On the other hand, the leadership training given to all veterinary students may have prepared them better for effective group work and made it possible for them to work well together in a single session. Finally, the test questions were created for this year, and bias may have been introduced toward or against one study group. However, a set of study questions was provided to both groups and test questions drawn from that material in an attempt to minimize variation. In general, we recommend TBL for larger units of courses or for any new course unit. We found we were able to successfully run the class in a TBL format despite only having three hours of regular contact time (1.5 hours of TBL time). However, the unique format required advanced preparation for both students and instructors and created stress related to the differences from regular coursework. In the future, we will spend more effort focusing student reading requirements on the core material and will include more short videos instead of just providing the PowerPoint slides, as students felt overwhelmed and found it harder to review the slides on their own. With more courses using TBL or more sessions in a single course, students should likely be less worried about the course design and their roles. With larger instructional units, the general preparatory work (creating group folders, peer review forms, etc.) would be fewer hours in relation to contact time; repeated offerings of TBL are reportedly much less time-consuming, as well (Thompson et al., 2007; Mennenga & Smyer, 2010). Students may also be more successful with more practice with self-study and with enhanced group dynamics, particularly if they do not have previous training in effective group skills. In the future, we plan to convert course sections or courses to TBL if there are at least three classroom sessions

(equivalent to at least nine hours of regular contact time) to balance the set up demands and allow groups to mature. We have already started to use TBL for new instructional units no matter the length and have been working with colleagues to assist more widespread adoption of TBL in the veterinary curriculum.

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Appendices

Appendix 1. Questions from the Urinary Systems Disorders Examination.

1. You are presented with a 2 day old colt that you suspect has a ruptured bladder. Which of the following is consistent with your diagnosis?
    a. the foal strains to urinate and has a pulsating urethra
    b. peritoneal and pleural effusion can lead to poor oxygenation
    c. hypokalemia, hypoglycemia, and hyponatremia
    d. serum creatinine is 2x abdominal fluid creatinine

2. You recommend surgery as soon as anesthesia can get set up in order to minimize adhesions from the intraperitoneal urine
    a. True
    b. False

3. For the same colt, what is recommended in terms of fluid supplementation prior to surgery?
    a. use fluids low in sodium to correct hypernatremia
    b. add dextrose to minimize cardiac abnormalities
    c. use LRS to provide proper levels of calcium
    d. add potassium since he is off feed

4. You are presented with a calf with an umbilical swelling. The swelling is reducible and the calf seems sensitive to palpation. The calf has a temperature of 103F. With deep palpation you note the structure seems to extend cranially. On ultrasound you do identify a thickened structure extending from the umbilicus to the liver. You suggest treatment will likely involve:
    a. Removal of the entire infected urachus
    b. Removal of the entire infected umbilical vein
    c. Removal of the entire infected umbilical artery
    d. Marsupialization of the infected umbilical vein
    e. Marsupialization of the infected umbilical artery

5. You did surgery to repair an umbilical hernia on a calf. What might be included in your postoperative instructions?
    a. keep on broad spectrum antibiotics (penicillin/gentocin) for 5 days postop
    b. monitor temperature until suture removal; call if >99F
    c. stall rest until suture removal (10-14 days) then turnout with only 1-2 calves
    d. monitor incision daily until suture removal: call if any heat, pain or discharge

6. You are called out on emergency after a rough calving on a nearby farm. They got the calf out before you arrived but it took a lot of work. You notice that the cow has a third degree rectovaginal tear (big open hole between the rectum and the vagina that extends about 6” deep). This is one of their best cows so they want to do what you think is best, Doc. You recommend:

a. we should refer this cow to the UMN. She needs to have surgery done tonight to repair this tear or she will be contaminating her peritoneal cavity
b. we should refer this cow to the UMN. This type of tear needs to be repaired as soon as possible but it is tricky and best done in a sterile surgery room
c. we should fix this cow tonight; I can do it here if you can get me a good light. Luckily these tissues heal quickly so she has a good chance of coming out of this just fine
d. we should fix this cow if you want to breed her but we need to wait a few weeks. If I fix it tonight, it will just fall apart again. I am going to get her started on some antibiotics and flunixin meglumine and will check on her again in a couple of days

7. Treatment of pneumovagina in a mare would most likely include which of the following?
    a. Regular aspiration of air
    b. Performance of a Caslicks
    c. Ensuring ventral drainage
    d. Creation of a cervicopexy
    e. Insertion of a Buhner stitch

8. Which of the following steps is incorrect when performing a caslicks?
    a. secure the tail out of the way by attaching it to the horse's neck
    b. inject lidocaine along the edges of the vulvar lips
    c. trim a small margin of tissue from each side of the vulva to create a fresh edge
    d. appose the fresh edge to the other side of the vulva with a simple continuous pattern
    e. leave a small opening proximally to allow urination

9. The perineal body is
    a. benign growth that is frequently identified in maiden (unbred) alpacas
    b. the reason you can't pass a urinary catheter into the bladder of a goat
    c. a structure that provides support to the dorsal aspect of the vaginal vault
    d. a remnant of a mesonephric duct, commonly found in XXY animals

10. You are a food animal vet and go out to check on your neighbor's herd of beef heifers. He is a gentleman farmer and isn't at home much and doesn't know much about cattle (they are mostly a tax write off). One has a large swelling protruding from her vulva. He reminds you he expects them to start calving in the next month. After getting the swelling back in where it belongs, you recommend which of the following :
    a. You recommend a C section now and then shipping the cow as she is likely to prolapse her uterus after calving
    b. You recommend a C section now as the cow is going to die soon and you can try to salvage at least one of the pair
    c. You will perform a Buhner stitch and everything should be good until after the calf is born
    d. You will perform a Buhner stitch and take this one to your barn for close monitoring until after the calf is born

11. You are presented with a 6 month old intact (not castrated) bull calf, intended for breeding, with a 4 day history of stranguria. You palpate pulsations along the ischial urethra. Ultrasound reveals a grossly enlarged bladder. Which would provide the best chance of resolving the urethral obstruction while preserving the bulls breeding potential?
    a. retrograde (eg from penis end) urethral catheterization and urethral lavage
    b. ischial urethrostomy and placement of a catheter to keep the bladder empty
    c. amputation of urethral process tonight with cystotomy tomorrow
    d. celiotomy for placement of a Foley catheter within the bladder
    e. placement of a chest drain to remove the urine and iv fluids to flush the bladder

12. You diagnose a bladder stone in a horse and successfully remove it via a perineal urethrotomy approach. Which of the following is most likely to be included in your discussions with the owner?
    a. management of the associated postrenal azotemia
    b. dietary suggestions about their current use of a grass-alfalfa mix hay
    c. the risks of body wall herniation after this type of surgery
    d. clinical signs such as stranguria that will alert them to a new stone
    e. the technique of urethral dilatation if they catch the problem early enough

13. You suspect a ruptured urethra in a feedlot steer. Treatment would primarily require :
    a. correcting electrolyte abnormalities
    b. lancing the skin in the area to allow drainage
    c. inserting a chest tube to drain the urine
    d. no treatment; just send him directly to slaughter

14. Your client's favorite stallion gets kicked by a mare. You haven't seen it yet but they call wanting to know if it warrants an emergency call. You answer
    a. it can wait. Stallions usually don't rupture the tunica albuginea as happens in bulls
    b. it can wait. However, if he develops a persistent erection, they should call you right away
    c. most definitely. Better to be safe than sorry. Sometimes they damage the urethra and that would lead to impaired fertility
    d. most definitely. Trauma to that area leads to swelling that could eventually make him infertile

15. A beef breeding bull develops a large, firm, swelling surrounding the penis, just cranial to the scrotum. The bull is unable to extend the penis. What is the most likely cause of these findings?
    a. hematoma involving rupture of the tunica albuginea
    b. squamous cell carcinoma in the region of the fornix
    c. urethral rupture and leakage of urine into tissues surrounding the penis
    d. seroma associated with lymphatic blockage
    e. granulomatous response to a foreign body in the fornix

Appendix 2. Classroom engagement survey questions.

Lecture Group	
mins: 10 20 30 40 50 60 70 80 90 100 110 120	
Quadrant: 1 2 3 4	
	YES
general participation (raising hand, etc)	
listening to instructor (head nod, eye contact, etc)	
listening to group	
talking to group (on topic)	
talking to group (off topic)	
asking instructor questions	
answering questions	
working on other homework/studying for other classes/ busywork	
reading	
organizing ideas	
writing	
texting	
on computer (on task)	
on computer (off task)	
slumped back in chair	
leaning forward, engaged	
chairs moved so that everyone in group is included	
chairs moved so that most of group is involved	
1-2 outsiders in group	
no furniture moved	
hostile debate in group	
friendly debate in group	
even voice distribution	
1-2 people running the show	
group has divided into sub groups	
everyone in group is taking equal ownership for ideas	
eye contact	
paying attention to group	
paying attention to other groups	
attention has been lost	
asking peers questions	
using "majority rules" to make decisions	
making decisions based on best reasoning	

Appendix3. Student evaluations of TBL section.

	# responses
I was surprised at how much I already knew going into class (before discussion)	
Definitely surprised	6
Maybe a bit	16
Not at all; I knew what I knew	9
I reviewed material prior to class	
0hr	0
<1hr	2
1-2 hrs	22
2-3 hrs	6
>3 hrs	1
I used the supplementary readings (not just notes/powerpoints)	
Yes, I read more than one	2
Yes, I read one	2
No, stuck to notes/powerpoints	27
During class, I felt	
I was not challenged at all	0
Comfortably challenged	25
In way over my head	6
I feel that I could apply the material to a real life case	
Yes, definitely	17
Maybe	11
Not without more help	2
I feel that it was easy to ask questions	
Very easy	26
Not very easy, but doable	5
Not at all	1
I felt that it was easy for me to express my ideas within my team	
Very easy	27
Somewhat easy	4
Difficult	0
I feel that my team accomplished	
A lot in terms of better understanding material	28
Not a ton. I feel that I know about as much as before I met with my group	3
Nothing. The class was counterproductive. I am more confused.	0
I felt that	
My group was very focused during the entire class	25

Was focused, for the most part	5
Was unfocused	0
Overall, I liked the class format	
Yes, definitely	20
It was okay	10
I would rather have had a different format	1
Other things I (probably) did during class (Check all that apply)	
None	26
Email	4
Facebook	3
Study for other exams	
Played games/did crossword	
If I did others things during class, it was most likely for	
< 1/4 of class	6
1/4-1/2 of class	
1/2-3/4 of class	
> 3/4 of class	

What I liked:
It was more interactive than a typical lecture.
Open discussions helped hold attention
Being able to talk the cases through
The ability to apply knowledge and further clarify topics
Small
groups
Flexibility to study
Allowed for multiple viewpoints to be considered
Teamwork allowed for better understanding
Easy to ask questions
Fun
Less pressure
Real life scenarios

What I disliked:
Combined with the out of class work, it was longer than we'd spend in a normal class
The powerpoints/notes were sometimes hard to understand on their own.
Not enough time to read the lecture beforehand/ lots of information to get through prior to class
Some people were not on task and caused disruption
The independent quizzes
The suggested 90 min review of the material prior to class was not enough time
The amount of material we had to get through
Lots of material that we didn't touch on was in the notes we were told to review before class

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