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Autonomic Nervous System Team-Based Learning Module

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Abstract

Introduction: The team-based learning (TBL) instructional strategy promotes learning and retention, enhances student engagement, allows for a deeper understanding of foundational and applied concepts, and helps students' develop lifelong learning skills. The autonomic nervous system (ANS) TBL was created for first-year medical students in the Neuroscience 1 course at Oakland University William Beaumont School of Medicine. **Methods:** The module covered the pathophysiology of ANS-related diseases and therapeutic agents that impact ANS function. By the conclusion of the module, students were able to diagnose different disease processes of the ANS, identify potential complications, and formulate appropriate management strategies. Four faculty members used backward design to create the ANS TBL. The preparatory assignment included reviewing content from previous didactic lectures and consolidating key information in provided tables. Key concepts were evaluated with readiness assurance tests. All application exercises adhered to the 4 S's. **Results:** Over the course of 2 years, the class averages for the individual readiness assurance test were 79.8% and 87.6%. The class averages for the team readiness assurance test and application exercises were similar across both years. Course evaluations revealed that students found the TBL relevant and valuable. **Discussion:** Similar TBL modules available on MedEdPORTAL are not integrated to include different aspects of the basic and clinical sciences. This ANS TBL was used to help students integrate several essential concepts, including neuroanatomy, neurophysiology, neuropharmacology, and clinical neurology. Students were very enthusiastic and engaged throughout the ANS TBL as it contained relevant case-based scenarios with questions that were meaningful for clinical practice.

Keywords

TBL, Team-Based Learning, Autonomic Nervous System, ANS, Instructor Guide

Educational Objectives

By the end of this team-based learning module, learners will be able to:

1. Evaluate signs and symptoms of autonomic nervous system (ANS) dysfunction to determine the mechanism of the disease.
2. Explain the effect on the body systems and the possible complications of ANS diseases based on their pathophysiologic mechanism.
3. Propose a treatment for diseases of the ANS based on their pathophysiologic mechanism.
4. Predict possible adverse effects of the proposed treatments based on their pharmacodynamic profile.

Introduction

Team-based learning (TBL) is a powerful instructional strategy developed by Dr. Larry Michaelsen, a professor of management at the University of Oklahoma, to facilitate learning in large classrooms.¹ TBL is different from traditional lectures and assessment methods in that it motivates students to become engaged in the classroom, allows them to work through complex problems, and tests what they can do rather than what they know. Since there are many advantages to using TBL over traditional instructional

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Appendices

- A. ANS TBL-Student Handout .pdf
- B. Adrenergic Pharmacology-Instructor.pdf
- C. Cholinergic Pharmacology-Instructor.pdf
- D. ANS TBL-IRAT & TRAT .docx
- E. Sample TBL Appeal Form .pdf
- F. ANS TBL-PowerPoint Presentation.pptx
- G. ANS TBL-RAT Response Rates.docx
- H. ANS TBL-Application Exercise Response Rates .docx
- I. ANS TBL-Application Questions Student Handout.pdf
- J. ANS TBL-Application Exercise Explanations.docx

All appendices are peer reviewed as integral parts of the Original Publication.

strategies, many medical schools routinely use TBL throughout their curriculums.¹ Students are able to develop a more in-depth understanding of course material and improve their critical thinking skills by working through real-life case scenarios with their teammates. They also learn to communicate effectively and to work as a team in a professional manner, both of which are important life skills for careers in medicine.

Several studies have shown that medical students gain more from TBL compared to traditional instructional strategies. For example, Koles, Stolfi, Borges, Nelson, and Parmelee analyzed the performance of second-year medical students on 28 comprehensive course examinations over 2 consecutive academic years.² They found that their medical students had higher performance on examination questions related to course content learned through TBL compared to other methods of instruction. The study also showed that struggling students may benefit more than high-performing students from the TBL instructional strategy. Zgheib, Simaan, and Sabra examined the effect of TBL on second-year medical students' performance.³ Compared to traditional instructional strategies, they found that TBL improved student learning of difficult questions, although it was less effective for simple questions.

Oakland University William Beaumont School of Medicine (OUWB) offers an innovative 4-year curriculum that vertically integrates the basic and clinical sciences. OUWB adopted the TBL instructional strategy because it promotes learning and retention of information, enhances student engagement, allows for a deeper understanding of foundational and applied concepts, and helps students develop lifelong learning skills. TBL is a large portion of the curriculum at OUWB as it provides an environment that allows students to develop the skills necessary to become successful, highly skilled, and compassionate doctors. At OUWB, the preclinical curriculum is organ-system based, in which the Neuroscience 1 course integrates the study of the central nervous system, including the fundamental concepts of neuroanatomy, neurochemistry, neurophysiology, and clinical neurology. At the end of the Neuroscience 1 course, first-year medical students participate in an autonomic nervous system (ANS) TBL module that covers different diseases of the ANS, as well as proposed treatments and potential complications. The ANS TBL module is one of two modules that are used within the 3-week Neuroscience 1 course. To give a better understanding of where the TBL falls within the course curriculum, below is the course schedule.

Neuroscience 1 Course Schedule

Week 1:

- Gross anatomy of the nervous system.
- Equilibrium potential and resting membrane potential.
- Graded potential.
- Nervous system histology.
- Nervous system cell biology.
- Action potentials.
- Neurotransmitters and synaptic transmission [covers content directly applicable to the ANS TBL].
- ANS [covers content directly applicable to the ANS TBL].
- Neural control of muscle contraction [covers content directly applicable to the ANS TBL].
- Peripheral nerve and spinal cord.
- Brain stem and cranial nerves.
- Limbic system.
- Diencephalon.

Week 2:

- Hypothalamus [covers content directly applicable to the ANS TBL].
- Cholinergics [covers content directly applicable to the ANS TBL].
- Anticholinergics [covers content directly applicable to the ANS TBL].
- Cerebrospinal fluid and ventricular system.
- Motor systems.

- Adrenergics [covers content directly applicable to the ANS TBL].
- Antiadrenergics [covers content directly applicable to the ANS TBL].
- Cerebellum.
- Basal ganglia.
- Cerebral cortex.
- Cerebrovascular anatomy.

Week 3:

- ANS TBL.
- Anatomical radiology of the nervous system.
- Nervous system infections.
- Neurotrauma.
- Nervous system embryology.
- Motor and sensory pathways TBL.
- Digital patient problem-solving session.

Week 4:

- Final exam.

By the conclusion of the module, students should be able to evaluate different disease processes of the ANS, identify potential complications, and formulate appropriate management strategies, including pharmacological treatment and monitoring plans.

There are several educational resources available through MedEdPORTAL that cover different aspects of the ANS. The TBL modules currently available on MedEdPORTAL, such as “Neurologic Localizations”⁴ and “Introduction to Autonomic Pharmacology,”⁵ cover concepts related to individual topics of the ANS but are not integrated to include different aspects of the basic and clinical sciences, such as anatomy, pathophysiology, and pharmacology. There are a number of multimedia tutorials and modules on the ANS available,^{6,7} as well as a simulation of organophosphate poisoning,⁸ but these educational activities are not presented in the integrated TBL instructional format preferred at OUWB.

Methods

Team Formation

Teams are formed with the use of GRumbler, a free computer software program created by Malcolm Sparrow that has the capability to generate diverse group assignments.⁹ In order to distribute individual strengths and make sure teams are well balanced, students are divided based on several different elements, including academic experience, health care experience, and gender. The teams contain five to seven students to maximize intellectual resources and individual participation. Michaelsen and colleagues noted that it is advantageous for groups to stay together for extended periods of time in order to benefit from the strengths of each teammate; therefore, the teams stay together for the entire school year.¹ To make sure groups are diverse and to prevent cliques from forming within teams, students do not form their own teams.

Description of Advance Preparation Resources

The session objectives and preparatory assignments for the ANS TBL are provided to the students 1 week prior to the scheduled TBL module. It is assumed that students have mastered the content in all of the autonomic sessions from the Anatomical Foundations of Clinical Practice Course in their first semester of medical school, and they are informed of this expectation.

For the advanced preparation assignment, students are expected to review several PowerPoint lectures from the Neuroscience 1 course. Although there are several lectures with substantial amounts of information, the required material is tested on the Neuroscience 1 final exam, which minimizes potential student complaints. In fact, a common theme in the course evaluations is student appreciation that the

ANS TBL covers material from the lectures that is then also tested on the final exam. As an alternative to using lectures, the preparatory material may include reading assignments from various textbooks. Our recommendations include chapters from *Basic & Clinical Pharmacology*¹⁰ and *Medical Physiology: Principles for Clinical Medicine*.¹¹ Please consult the Table for a list of content mapped to the readings by chapter.

Table. Advanced Preparation Readings

Book/Chapter	Topic
Katzung & Trevor, <i>Basic & Clinical Pharmacology</i> , 13th ed., chapter 6: Introduction to Autonomic Pharmacology	Autonomic nervous system (ANS) physiology <ul style="list-style-type: none"> • ANS functional anatomy • ANS neurochemistry • ANS effectors • ANS reflexes • ANS regulated behaviors
Rhoades & Bell, <i>Medical Physiology: Principles for Clinical Medicine</i> , 4th ed., chapter 8: Skeletal and Smooth Muscle	Neural control of effectors <ul style="list-style-type: none"> • Types of end effectors • Excitation-contraction coupling • Somatic spinal reflexes • Smooth muscle tone • Excitation-secretion coupling
Katzung & Trevor, <i>Basic & Clinical Pharmacology</i> , 13th ed., chapters 7: Cholinergic-Activating & Cholinesterase-Inhibiting Drugs and 8: Cholinergic-Blocking Drugs	Parasympathetic pharmacology <ul style="list-style-type: none"> • Mechanisms of signal transduction through muscarinic and nicotinic receptors • Physiologic response to parasympathetic stimulation • Impact of receptor selectivity of parasympathomimetic and parasympatholytic agents • Mechanism of action, receptor selectivity, physiologic and adverse effects, and common uses for muscarinic receptor agonists, muscarinic receptor antagonists, acetylcholinesterase inhibitors, pralidoxime, nicotinic receptor (N_N) antagonists, nicotinic receptor (N_M) antagonists, and succinylcholine
Katzung & Trevor, <i>Basic & Clinical Pharmacology</i> , 13th ed., chapters 9: Adrenergic Agonists & Sympathomimetic Drugs and 10: Adrenergic Antagonist Drugs	Sympathetic pharmacology <ul style="list-style-type: none"> • Mechanisms of signal transduction through alpha- and beta-adrenergic receptors • Physiologic response to sympathetic stimulation • Impact of receptor selectivity of sympathomimetic and sympatholytic agents • Mechanism of action, receptor selectivity, physiologic and adverse effects, and common uses for alpha-adrenergic receptor agonists, alpha-adrenergic receptor antagonists, beta-adrenergic receptor agonists, beta-adrenergic receptor antagonists, and drugs affecting the uptake, synthesis, metabolism, and release of norepinephrine and epinephrine

Students are also provided with a handout that includes the session objectives, preparatory assignments, and two worksheets to help them master the physiology and pharmacology of the ANS (Appendix A). The worksheets also list several cholinergic/anticholinergic and adrenergic/antiadrenergic drugs, as well as their clinical applications. Based on the specified information, students are expected to fill in each drug's receptor selectivity, mechanism of action, and adverse effects. Although the worksheets are not required, they are highly recommended. The instructor versions of the worksheets, with all answers filled in, are also included (Appendices B & C).

A comprehensive list of available tables from the recommended course textbooks is also provided. Students have electronic access to all books. Although optional, the list has been created to help students easily find information that pertains to the TBL. The tables may be used to help fill out the worksheets or supplement the lecture slides.

To correctly solve the questions posted in the application exercise, students also have to recall the following topics delivered in the Anatomical Foundations of Clinical Practice course (given the semester before the Neuroscience 1 course): cranial nerves, neck, thorax, and abdominal anatomy. Even though no specific preparatory material about these topics is assigned for the TBL, students are told at the beginning of the course that they are expected to have mastered all the material delivered in previous courses. This is critical in order to allow the integration of content across the curriculum.

Description of Readiness Assurance Process and Immediate Feedback

At the beginning of the TBL session, students are given an individual readiness assurance test (IRAT).¹² The ANS IRAT contains five multiple-choice questions to measure the students' comprehension of the advanced preparatory assignment (Appendix D). Scantron forms can be used for the IRAT. Following the

IRAT, the same multiple-choice test is retaken in groups/teams as a team readiness assurance test (TRAT).¹² The TRAT uses scratch-off answer cards known as immediate feedback assessment technique (IF-AT) cards.¹³ The IF-AT cards provide immediate feedback about the accuracy of the answers to each question. Teams are able to continue answering the questions until they discover the correct answer. A team is awarded full credit if the correct answer is uncovered on the first scratch and progressively loses credit with each additional attempt to find the correct answer. Both the IRAT and TRAT are closed book; therefore, students are not allowed to use any notes, books, or other materials.

Once the test period is completed, the instructors may clarify any difficult concepts that were not well understood during the IRAT and TRAT process using the provided PowerPoint presentation (Appendix F). Generally, instructors are able to quickly identify confusing points as they are able to see how many answer attempts it took for each team to discover the correct answer. Students should have a clear understanding of the preparatory material before moving to the more complex application questions.

Teams have the opportunity to fill out a question appeals form if they disagree with question keying or question wording or feel that the required reading was too vague or unclear. A sample version of this appeal form is provided in Appendix E. The appeals may be submitted only by a team (not by an individual) and must be submitted within 24 hours after the completion of the TBL. Multiple teams may not submit appeals using the same form; therefore, each team must submit its own appeal worksheet. Instructors review the appeals outside class time and report their decisions in a timely manner.

As the IRAT and TRAT are graded, multiple measures are taken to prevent cheating. All hard copies of the IRAT and TRAT must be returned with the students' names. If any quiz is not returned, the RAT questions are considered compromised, and new questions are necessary for TBL implementation in the future. Students are not allowed to take pictures of any material used during the TBL, including the nongraded activities. There is also an honor code that students are expected to follow. Any students who do not follow the rules are given a notice of unprofessional behavior and are required to meet with the faculty advisor of professionalism. Performance is tracked for all TBLs from year to year. A dramatic increase in performance has not been observed for the ANS TBL or other TBLs that have been used for many years; therefore, these methods are most likely effective for the prevention of cheating.

Description of Team Application Activities

The final components of the TBL module are the application exercises. Appendices I and J contain a student handout for the first application question and explanations of the application question answers, respectively.

In this portion of the TBL, teams use their foundational knowledge gained from the advanced preparatory material and RATs to solve complex problems.¹² This is considered the most important aspect of the TBL instructional strategy as it requires higher order thinking and aids in the development of critical thinking skills. The application questions must adhere to very specific criteria to be considered a true TBL module; each question must follow the 4 S's.¹² Specifically, the questions propose a *significant* problem and are based on important and relevant material to stimulate student interest and maximize effort. The questions are also administered at the *same* time, and each group must work on the same question to encourage meaningful discussion among teams, as students are more likely to have enthusiastic and enriching debates when speaking about their views of the same problem, rather than different problems. The questions also feature a *specific* choice, and teams are required to use their problem-solving skills to prepare arguments and create explanations for a specific choice or answer. Finally, the questions feature *simultaneous* reporting of the results to prevent teams from being influenced in their responses by other teams.

In the ANS TBL, the teams report their decision by holding up colored cards that indicate their specific choice. Teams are randomly selected to report their findings to the rest of the class. While the RAT questions are graded at OUWB, the application questions do not count as part of the course grade. Oftentimes, our application exercises are not black and white; in some cases, more than one answer may

be considered correct to some degree. We have found that ungraded application exercise questions decrease some of the anxiety associated with TBL but still promote problem solving through teamwork and dynamic group discussions.

Facilitation Schema

1. Advanced preparation assignment: Assign session objectives and advanced preparatory material 1 week prior to the scheduled TBL module.
2. RATs.
 - a. IRAT (6 minutes and 25 seconds total): Students are given 75 seconds per question.
 - b. TRAT (7 minutes and 25 seconds total): Students are given the same amount of time it takes to complete the IRAT, plus 1 additional minute.
 - c. Mini-lecture and clarification of difficult concepts (5-10 minutes total): Any confusing concepts can be clarified before the application exercises.
3. Application exercise (90 minutes): The majority of the class period should be spent on the application questions.
4. Postsession (24-48 hours): Students are given 24 hours to complete question appeals. Faculty should respond to all appeals in a timely manner within 48 hours of the session.

Results

First-year medical students were required to participate in the ANS TBL during their Neuroscience 1 course, which is the second organ-system course in the second semester of the medical school curriculum. Students previously completed several courses, including Biomedical Foundations of Clinical Practice, Anatomical Foundations of Clinical Practice, and the hematopoietic and lymphoid organ system course. The ANS TBL was used over 2 consecutive years, with a total participation of 222 students and 41 teams.

Four OUWB faculty members have been involved with the creation of the ANS TBL module, including the course director for the Neuroscience 1 course. Of the four faculty members, one is a content expert in neuroscience, one is a content expert in neurophysiology, and two are content experts in pharmacology. Two of the four faculty members are also members of the TBL Oversight Team at OUWB, in which capacity they have worked with several faculty members on the implementation of TBL modules.

After the TBL was implemented in 2015, minor modifications were made to improve the RAT questions and application exercises. In the winter semester of 2015, the class averages for the IRAT and TRAT were 79.8% and 99.0%, respectively. In the winter semester of 2016, class averages were 87.6% for the IRAT and 100% for the TRAT. Although the application exercises were not graded, teams performed similarly both years. A more-specific data analysis for each RAT and application question can be found in Appendices G and H.

Overall, students were very enthusiastic and engaged throughout the ANS TBL. They asked several challenging questions during the module, which led to stimulating debates and meaningful discussion. The students appreciated that the TBL material was relevant and that the application exercises allowed them to gain a more clear and thorough understanding of several different important concepts. The course evaluations contained numerous positive comments. Examples include the following:

- “The TBL sessions (especially the first one on the drugs) were the BEST TBL sessions we have ever had. Any other professors who run TBLs should be required to watch this TBL on Panopto—it was THAT good. Our class was actually excited after TBL about how much we had learned—that almost never happens. I think the success of the TBL was in the application questions. They challenged the concepts that we already knew, rather than asking extraneous, tricky, and irrelevant questions that required us to search through articles on PubMed.”

- “I really liked how the TBLs were based off more difficult information covered in lecture. I felt this was much more useful than reading an article. It forced students to be on top of their studying and it encouraged student engagement in TBL.”
- “TBL was done extremely right this time. The TBLs were on, arguably, the hardest material in the course (brainstem and pharmacology), and it forced us to prepare for it in advance. Having the TBLs back to back was tough, but since it was on lectures that were important for the final, I didn’t mind that.”
- “I thought that the TBL topics of this course were very applicable to what we were learning. I really liked that they were straight from lectures, but still integrated pharmacology with physiology. The Application Questions were also appropriate, in that they were making us think through things, but we weren’t having to solely rely on outside resources for the answers.”
- “I loved how the TBLs were on class material and NO extra material—it actually forced me to be prepared with the hardest material (i.e., pharm and the flipped classroom lectures) well before the exam so I could identify what I was struggling with. It also made sure that I couldn’t postpone learning the hardest material.”
- “I definitely also liked the fact that TBL helped us to really learn the critical lectures that presented difficult concepts like pharm, neuroanatomy, lesions really well.”
- “The TBL sessions were very valuable in our learning. They involved topics discussed in class and ones that were directly relevant to our current stage of learning. Though they had clinical significance they were not overly clinical to the point that it skews the foundational knowledge we are trying to learn.”
- “I also loved the TBLs—the material that was focused on was all extremely relevant and really forced us/helped us understand the information.”

Discussion

Horizontal integration challenges in the medical school curriculum often make it difficult for medical students to create the necessary connections in the basic sciences disciplines. The ANS TBL offers students the opportunity to understand how the different aspects of the ANS fit together, as well as to apply their knowledge to case-based clinical scenarios. The TBL instructional strategy was used to help students integrate several essential concepts of the ANS, including neuroanatomy, neurophysiology, neuropharmacology, and clinical neurology.

Reflection of the TBL Process (Design, Development, Evaluation, Dissemination)

The ANS TBL was designed using the backward design process, initially described by Wiggins and McTighe,¹⁴ in which we initially decided on the final learning outcomes that we wanted our students to be able to do at the end of the TBL. Next, we developed the team application exercises to ensure that our specified learning outcomes could be achieved through critical analysis, problem solving, and teamwork. We then created the RAT questions and developed the preparatory material to make sure the students were well prepared to participate in a meaningful discussion. The design and development of the ANS TBL were completed over 5 months, as the involved faculty members met several times to determine relevant learning outcomes and develop the RAT and application questions. Faculty members also worked on the TBL material on an individual basis. There were multiple discussions and clarifications prior to agreeing on the finalized material.

To make the TBL as valuable a learning experience as possible, the development of significant and relevant questions was key. Organophosphate poisoning was chosen for one of the application case scenarios for several reasons. First, both the parasympathetic and sympathetic nervous systems are affected, therefore requiring students to have a clear understanding of the effects that neurotransmitters of the ANS have on various organs, as well as the potential similarities and differences in both pathways. Second, students are also required to determine whether continuous exposure to neurotransmitters resulted in responses such as desensitization or continuous excitation. With organophosphate poisoning, students are also required to explore a wide range of pharmacological issues, since the treatment not only

involves a global measure (atropine) but also includes targeted therapy for symptoms that do not respond. In addition, because organophosphates are a common method for attempted suicide worldwide¹⁵⁻¹⁷ and also have the potential for use as a chemical weapon,^{18,19} they are a hot topic from the perspectives of public health and the Liaison Committee on Medical Education. After much discussion, we felt the TBL could be expanded to cover other clinical scenarios as well. For example, although pheochromocytoma is rare, it provides an excellent learning opportunity for students in the area of clinical decision-making and the integration of pathophysiology and pharmacology, including mechanism of action and adverse effects of pharmacological treatment.

One of the advantages for all aspects of the TBL process, including the development, facilitation, and evaluation of the ANS TBL, was the significant involvement, diverse background, and distinct expertise of each faculty member. Each faculty member was comfortable teaching various aspects of the Neuroscience 1 course, allowing for a more efficient yet in-depth review of material that should be included. Working together to create RAT questions and, more importantly, application exercises allowed us to create an integrated TBL module with relevant case-based scenarios and questions that were meaningful to clinical practice. The use of four different facilitators also alleviated some of the stress during the actual implementation of the TBL. While one or two of the faculty members facilitated discussion, the others could operate the computer-based response and time display systems, as well as take notes for any potential improvements in future years. Students also benefited from the varied background and expertise of each facilitator, as they were provided with more comprehensive explanations to any questions and concerns.

Challenges Encountered

Neuroscience 1 is a 3-week course in which a significant amount of important information must be presented in a short period of time. Students are exposed to and required to learn many new and difficult concepts in a limited amount of time; therefore, student buy-in for the TBL may be challenging if students are more comfortable listening to traditional lectures and studying class notes. Also, since the course is short, the TBL must be carefully placed in the course sequence, with sufficient time between the didactic lectures and the TBL. Otherwise, students will be unduly stressed and have a difficult time learning the basic science information before applying the concepts in a meaningful way.

Insights Gained

As stated previously, the 3-week time slot allotted for the course required students to learn significant amounts of vital information in a short period of time. Based on previous TBL experiences, providing students with additional review articles or research papers for the preparatory material often causes additional stress, especially when the TBL is scheduled near the final exam. Instead, in the ANS TBL, students were required to review material learned throughout several of their lectures. Since the lecture material was relevant for the final exam and the TBL module, students felt more comfortable spending their time studying the preparatory material and came more prepared for the TBL. Although review articles and research papers are also nice tools for preparatory material, we found that students appreciate material from previous lectures being used since it reassures them that the material covered in the lectures and TBL will also be tested on the exam.

In addition to the required preparatory material, we also provided students with tables that contained drug names (i.e., cholinergic/anticholinergic, adrenergic/antiadrenergic) and indications. Students were given the opportunity to complete the tables, which included filling in the mechanisms of action and potential adverse effects. The tables narrowed the scope to a smaller group of drugs but allowed the list to encompass a wide range of drug classes. This also allowed the students to directly compare and contrast principles of pharmacology and physiology.

Future Opportunities

The OUWB Center for Excellence in Medical Education recently created faculty development opportunities aimed at helping biomedical science faculty incorporate biomedical and clinical material into the curriculum in order to foster true vertical and horizontal integration.²⁰ Although the ANS TBL was created

for first-year medical students, it may be beneficial to modify this TBL for students in their third- and fourth-year clerkships. Since the ANS TBL integrates several important concepts of the ANS, such as neuroanatomy, neurophysiology, and neuropharmacology, it may remind students of several basic science concepts that can be used during their clinical rotations. Integration of basic sciences and clinical skills is often difficult, but necessary, for medical students. Reviewing important basic science concepts during clerkship rotations may help support the effort to promote problem-based learning and teamwork throughout the medical school curriculum and aid in the development of the critical thinking skills necessary for lifelong learning.

Planned Revisions

According to the Neuroscience 1 course evaluations, the ANS TBL was reported as one of the most valuable TBLs at OUWB; therefore, few changes were required. However, in an effort to improve the ANS TBL, modifications were made to the RAT questions and application exercises after each run-through. Specifically, after the winter 2016 administration, one of the RAT questions caused significant confusion among the class as two answers were accepted due to poor wording in the answer choices. The question will be replaced in future TBLs. Within the application exercise, one of the figures (Case 1, Question 2) was modified. In the question, students were expected to understand gating transitions as they related to ligand binding. Most teams knew that the muscle weakness was due to receptor desensitization but were unable to choose the correct answer as they found the figure difficult to interpret. Outside of these implemented revisions, there are no other planned modifications to the ANS TBL. We will continue to evaluate the effectiveness of questions used during the TBL, especially when changes are made to the curriculum.

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