Team-based learning (TBL): A highly interactive teaching strategy successfully used in the Plains medical school curriculum

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Background

In 2021, CUSOM embarked on a longitudinally integrated curriculum based on the metaphor of climbing a mountain, ascending from the plains to the summit. A guiding principle for the new curriculum is to use evidence-based educational strategies that promote active learning and deeper retention of material. The Hematologic & Lymphatic Systems course happens during Fall of the Plains (first) year, early in students' medical school journey and is the first systems-based course of their curriculum, covering the hematologic and lymphatic systems. Here, we describe the incorporation and use of team-based learning (TBL) in the "Heme & Lymph" course as a means of achieving these goals and present initial outcome data showing its successful implementation.

Methods

In order to prepare for TBL, students are assigned 'prework,' which consists of brief videos and accompanying materials made by experts on campus. Students are divided into 3 groups (A, B, and C), and each group is assigned prework unique to their group, which allows for a manageable amount of prework (approximately 60 minutes) prior to the TBL event, usually completed on Sundays. On Mondays, students receive lectures on normal physiology, learn about related lab studies and are presented with an algorithm to help them apply this basic information to develop differential diagnoses. Prior to the Tuesday TBL event, students take an individual readiness assessment test (iRAT). At the TBL event, students from each of the 3 prework groups (A, B, and C) are assigned to stable small groups and take the same test together (tRAT), this time while sharing information and teaching one another. With this "jigsaw" method, each student brings unique knowledge "pieces" that they share with one another to solve "puzzles," such as clinical cases. Throughout the event, an audience response system is used to promote discussion. Regardless of which prework group a student is assigned, they are expected to know all material by the end of the week. Thus, on Thursdays, students work through more cases in a small group format with groups led by experts on campus then end the day with an interactive review session to solidify and receive real-time feedback on their knowledge and its application. Students then sit for their end of week or end of course assessment on Friday. Each week of the course focuses on a theme: anemia (week 1), bleeding or clotting problems (week 2), and immunodeficiency (week 3). Below are details using week 1 of the course as an example.

Week 1: Chief Concern of Anemia

	Pre-work	Monday	Tuesday	Wednesday	Thursday	Friday
8-9 AM	Topics: **Anemia** 1. Pancytopenia 2. Iron deficiency 3. B12/Folate deficiency 4. Anemia of chronic disease 5. Other underproduction anemias 6. Hemolysis 7. Hemoglobinopathies 8. Thalassemia 9. G6PD, PK deficiency 10. Membrane defects 11. Autoimmune hemolytic anemia 12. Microangiopathic anemia 13. Splenectomy 14. Iron metabolism and iron overload **Anatomy** 1. Anatomy Lab introductory video 2. Readings on body donation and dissection **For Tuesday** TBL pretest	Course overview and organization	TBL: Use and interpretation of laboratory studies to diagnose anemias	Clinical Skills/ Preceptorship/ Unstructured time	Preceptorship/ Unstructured time	
9-10 AM		CC: Pallor/Fatigue				Assessment
10-11 AM		RBC cytostructure and metabolism Hemoglobin				Vista
11-12 AM		O2 Dissociation Curve Erythropoiesis				Facilitated Review
12-1 PM		Anemia Algorithm Lunch	Lunch	Lunch	Lunch	Lunch
1-2 PM		Intro to Anatomy Lab	Clinical Skills/ Preceptorship/ Unstructured time	Health & Society	ABO/Rh0 blood systems	Preceptorship/ Unstructured time/ Office hours
2-3 PM		The CBC			Anemia Small Group Cases	
3-4 PM		Histology: Peripheral Blood Smear and Bone Marrow			Anemia Interactive Review Session	
4-5 PM						

Results

The course and TBL sessions have been delivered twice. Feedback from students has been positive. Between 67% and 85% of students responded that the TBL sessions were very or extremely effective. Evaluation comments revealed that students enjoyed the active learning from the TBL sessions while also sometimes struggling as the activity pushed them just out of their comfort zone (see selected student comments). Test scores showed an increase from the iRAT (range 48-72% correct) to the tRAT (range 90-95% correct), indicating the positive effects of peer teaching (see graph). Students performed well on their end-of-week and end-of-course assessments, made up of board-style clinical vignette questions, with no students failing the course.

Instructions for students

Team Based Learning (TBL)

- Focus is on problem solving

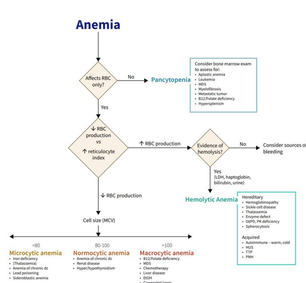
- Tuesday: Groups of 6 or 7 students – randomly assigned (look in North Star)
  - ➢Sit with your group tomorrow morning
  - ➢Note that it's a different room than this one – Ed2N 2104
  - ➢Groups will stay the same through the 3-week course
- For the Team Test - One of students will be entering answers for their group

Example prework video discussing thalassemia

Thalassemia - Pathophysiology

- Imbalanced globin chain production
  - Excess globin chains can form unstable tetramers or be oxidized to form hemichromes which generate ROS
- Chronic hemolysis
  - ROS damage red cell membrane proteins
  - Decreased red cell deformability
  - Increased binding of IgG and C3 to red cell membrane → clearance by splenic macrophages
- Ineffective erythropoiesis
  - Premature apoptosis and maturation arrest during erythropoiesis
  - Expansion of erythroid precursors pool in the bone marrow
  - Extramedullary hematopoiesis
- Iron overload
  - ↓ hepcidin → ↑iron absorption

Anemia Algorithm



Sample TBL questions

1. Which of the following sets of studies is most consistent with a diagnosis of iron deficiency anemia?

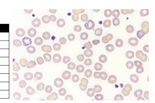
	Set 1	Set 2	Set 3	Set 4	Reference Range
Hgb (g/dL)	9.9	7.7	12.2	11.0	12.0 – 15.5
Hct (%)	29	24	36.4	33	36 - 48
MCV (fL)	64	73	75	80	80.0 - 100.0
RDW (%)	13.1	18.1	14.0	12.4	11.7 - 14.2
Reticulocyte count (%)	1.0	2.4	1.9	0.8	0.4 - 1.7
Ferritin (ng/mL)	140	11	20	63	12-160
Serum Fe (µg/dL)	107	18	29	24	30-160
Total Iron Binding Capacity (TIBC) (µg/dL)	196	380	247	155	200-400
% Saturation (%)	55	4.7	11.7	15.5	15 - 55

A. Set 1
B. Set 2
C. Set 3
D. Set 4

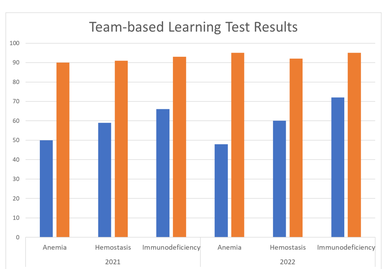
5. A 3-year old male presents with pallor, fatigue, and failure to thrive. He is severely anemic. High-performance liquid chromatography (HPLC) analysis of his red blood cells (RBCs) is performed and the results are shown below. What is the most likely diagnosis?

A. Beta-thalassemia major
B. 4-gene deletion alpha-thalassemia
C. Hemoglobin H disease
D. Hereditary persistence of fetal hemoglobin (HPFH)

	Results	Reference Range
WBC	9.3 x 10^3/L	5 – 16 x 10^3/L
Hgb	9.5 g/dL	11.5 – 13.5 g/dL
Hct	29%	34 – 40%
MCV	68 fL	75 – 90 fL
MCH	22 pg	24 – 30 pg
RDW	16.8%	11 – 16%
Platelets	436 x 10^3/L	150 – 400 x 10^3/L
Reticulocyte count	0.9%	0.4 – 1.7%



What lab test should be obtained next?
A. G6PD level
B. Iron stain
C. Lead level
D. Supravital stain



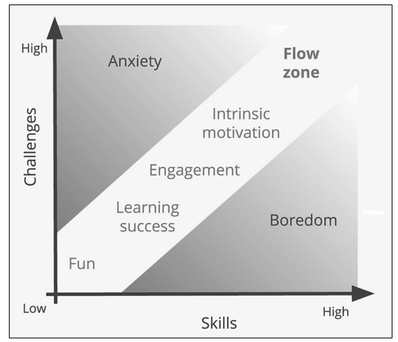
Selected Student Comments

- I really enjoyed how much PRACTICE we got. It helped the material stick. I prefer having a lot of prework and being able to work through confusions in class to sitting in lectures all the time.
- Learning the diseases via the prework videos and associated materials, while focusing on physiology, testing, and case-based learning in class, was a challenging modality but ultimately highly effective for learning. By having to work through the disease processes on my own, I feel I ultimately developed a stronger understanding than if they had just been introduced in lecture. This was an uncomfortable way to learn but was effective.
- The team-based learning, small group sessions, and facilitated review were excellent! This helped my learning tremendously. It also helped me apply what I was learning to clinical presentations and treatment. For the first time I felt like I was doing "Dr stuff", which was rejuvenating.
- The prework and Tuesday TBL's were incredibly engaging and a FANTASTIC way to structure our learning.
- In particular, I loved how the Sunday prework presented us with clinical context for the more basic science we learned Monday and how we were given ample opportunity to reinforce the material through Monday prework quizzes and TBL and small group cases.
- I absolutely loved that we received most of the week's content on Monday and then the rest of the week was application/practice. I thought the course was structured extremely well and the TBLs did a great job of solidifying knowledge and exposing us to different cases and potential exam questions.
- I really liked the early on, in person team-based learning with real clinical cases. They put the emphasis on why this all matters perfectly and you could feel your progress by the time you made it to Thursday/Friday. It was great to realize how much you learned over the week and how clinically applicable that knowledge was!
- The ability to clinically apply what we were learning in class to cases felt extremely relevant to what we will need to do in the future, and it was extremely productive towards learning and helped me understand the material significantly.
- TBL was a really great way to learn information in chunks and learn from my peers. Plus, I really enjoyed having the team-based problems in class where I could bounce ideas off my peers and hear how they understood different aspects of the curriculum throughout Heme and Lymph.
- Every single time I left TBL I was excited to learn more about blood disorders.

Discussion

Our findings indicate that TBL is an innovative and practical active teaching method that can be successfully implemented and well-received even by very junior medical students. It can provide a rich, interactive educational experience in both the large (Anschutz Medical Campus ~160 students) and small (Fort Collins Branch ~20 students) group setting, offering a small group-type experience while not requiring recruitment of large numbers of faculty.

TBL can push students out of their comfort zone, which can make them uncomfortable but can also prevent boredom and make them more receptive and engaged with the learning process. The goal is to provide enough challenge but not to make it so challenging that it leads to anxiety and loss of engagement, hitting the sweet spot of active learning.



Csikszentmihalyi, M. (2008). Flow: The psychology of optimal experience. Harper Perennial Modern Classics; 1st edition

With TBL, students can master and apply surprisingly advanced concepts in a relatively brief timespan. While TBL is challenging for students, requiring self-motivation and application of facts rather than rote memorization, it allows students to see the relevance of the material they are learning through direct application, to consolidate the information, to identify areas of weakness or misunderstanding and to enjoy problem solving and thinking like a physician.

Disclosures

None

References

Michaelsen LK, Parmelee DX, McMahon KK, and Levine RE (Eds.). (2008). *Team-Based Learning for Health Professions Education* (1st ed.). Stylus Publishing, LLC.