Active Learning in Medical School: A Comparison of Approaches for Interdisciplinary Teaching of Genetics and Pharmacology

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ABSTRACT

Active learning is an approach to instruction that helps students stay engaged during class by applying their knowledge for higher order thinking and problem solving. Studies have shown that an outcome of active learning is increased retention of knowledge compared to traditional lectures. The Liaison Committee on Medical Education (LCME) has embraced active learning and medical schools across the United States are changing their curriculum to incorporate different forms of active learning for all (or some percentage) of total classroom time for pre-clinical materials. To work successfully, active learning requires that students: 1) study materials by learning *de novo* for the session, or 2) recall knowledge learned previously in earlier sessions, or 3) a combination of both studying *de novo* and recall. When problem solving occurs in groups, students have the added benefit of brainstorming together to solve problems while teaching each other. We delivered a two-hour session entitled "Targeted Cancer Therapies"; this topic covers cutting-edge concepts and essential principles of interdisciplinary work in genetics and pharmacology. We designed and compiled prework to be read prior to class that jointly integrated knowledge from these disciplines. The "Targeted Cancer Therapies" session was taught by two methods: 1) standard Team-Based Learning (TBL), and 2) mini-lectures interspersed with group problem solving, called Large Group Active Learning (LGAL). The multiple choice and application questions posed to medical students were similar for both sessions, regardless of the methodology used in the classroom. A significant difference between these methods was that for TBL, resulting scores counted towards students' final grades whereas for LGAL, answering questions successfully in class was its own reward. We present highlights of the materials used and a compilation of students' comments as well as faculty conclusions from comparison of these active learning strategies.

GOALS FOR ACTIVE LEARNING

Our setting is a medical school with 60 first year students who experienced the topic in a two-hour Team-Based Learning (TBL) session compared to 90 first year students who experienced the topic in a two-hour Large Group Active Learning (LGAL) session. For both content delivery methods, students were assigned similar pre-work which involved reading and study prior to the classroom sessions.

- ❖ **Development of an Active Learning Environment** - Prior faculty experiences with classroom lecturing were combined with faculty training in different active learning pedagogies. Our fundamental philosophy was to encourage self-directed learning <u>prior to class</u>, so students could focus on applying what they had learned <u>during class</u>. Active student engagement was achieved by creating sessions that comprehensively and fairly tested and challenged their knowledge of concepts and facts learned from the pre-work during the TBL and the LGAL, respectively. A subset of multiple choice questions were designed as "application questions" which required a synthesis of knowledge in order to reach the final answer.
- ❖ **Setting Expectations** – The expectations for both TBL and LGAL sessions were made clear to all students during Orientation, so that students had a clear understanding of how classroom sessions would work right at the start of their first year.
- ❖ **Team Problem Solving** – The Office of Medical Education decided at the beginning of the semester which students would be on each TBL team. Faculty decided the number of students that would work together on a team to solve problems during the LGAL.
- ❖ **Expertise of Faculty Session Leaders** – For creating an interdisciplinary session that relies on integrating foundational knowledge in both Genetics and Pharmacology, it is essential to have experienced faculty who are experts in each discipline. Dr. Siracusa and Dr. Coffin have >20 years experience performing research and teaching in Genetics and Pharmacology, respectively. In addition, they both earned the certificate of "Knowledge of the Fundamentals of TBL" from the Team-Based Learning Collaborative (TBLC) (http://www.teambasedlearning.org/).

CLASSROOM EXPECTATIONS

The process for engaging students during class involved providing the learning objectives and pre-work one week in advance on the class website. Expectations of studying pre-work along with the pedagogy (TBL or LGAL) was also known to students in advance of class.

LEARNING OBJECTIVES

1. Review the general classes of cancer therapies (surgery, radiation, chemotherapy, immunotherapy).
2. Distinguish the characteristics of general chemotherapies vs targeted chemotherapies for cancer treatment.
3. Review the types of genomic alterations found in cancer cells.
4. Describe targeted therapies for mutations in oncogenes.
5. Describe therapies targeted at novel products of gene fusions found in cancer cells.
6. Explain the concept of synthetic lethality, the genetic requirements needed, and the resulting targeted therapies.
7. Name the main mechanism of action for each targeted cancer chemotherapy.
8. List the common side effects of targeted cancer chemotherapies.
9. Describe how therapeutic intervention may initially decimate cancer cells but inadvertently provide selective pressure for the emergence of resistant variants.
10. Describe genomic testing in oncology and explain how it can be applied to individualize diagnosis and treatment.

PRE-WORK

- ❖ **Overview –** NCI Targeted Cancer Therapies www.cancer.gov/about-cancer/treatment/types/targeted-therapies/targeted-therapies-fact-sheet
- ❖ **Study Guide –** Explanation of the topic with diagrams of cancer pathways
- ❖ **The Drug List –** Cancer Targets and Features of Selected Therapies
  Gene Fusions - IMATINIB, CRIZOTINIB, LAROTRECTINIB
  Synthetic Lethality - OLAPARIB
  Specific Mutations in Driver Genes - VEMURAFENIB
  Tyrosine Kinase Inhibitors - ERLOTINIB, LAPATINIB, SORAFENIB
- ❖ **Videos of drug mechanisms of action**

PROBLEM SOLVING

- ❖ **Multiple Choice Questions –** Questions are written in the style recommended by the National Board of Medical Examiners (NBME.org). The item stem is usually a clinical case with 4 - 7 plausible answers.
- ❖ **Each question is displayed on the screen -** teams have a specified amount of time to discuss and commit to their answer. At the end of the time limit, one team member will hold up their team's consensus answer. Students then discuss the reasons why they chose their answer prior to reveling which answer is correct.
- ❖ **Example of a Question –** A 71-year-old woman who had never smoked was diagnosed with adenocarcinoma of the lung, stage IV. She was tested positive for a mutation in the epidermal growth factor receptor (EGFR). She responded very well to a drug that targeted the ATP binding site of EGFR. Which of the following pairs correctly matches the drug used in this patient and the drug's mechanism of action?

  A. Crizotinib - an angiogenesis inhibitor
  B. Sorafenib - an inhibitor of the VEGF/PDGFR signaling cascade
  C. Vemurafenib - a mutated BRAF-kinase specific inhibitor
  D. Erlotinib - a tyrosine kinase inhibitor

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ARTWORK

http://cliparts.co/people-working-together-images
http://www.fotosearch.com/photos-images/together.html
http://newageimagery.com/designs/strategy

COMPARISON OF TBL & LGAL PEDAGOGIES

FEATURES	TBL	LGAL
Number of Students	57	91
Team Size	6	3
Foundational knowledge	10 MCQs	9 MCQs
Testing Methods	Individually first, then together with team	Answered as a Team first, then all together as a class
Graded	YES	NO
Application Questions	3 MCQs	2 MCQs
Graded	NO	NO
Material tested on the Final Exam	YES	YES

ABBREVIATIONS: TBL – Team-based Learning; LGAL – Large group Active Learning; MCQs – Multiple Choice Questions

STATISTICAL ANALYSES OF STUDENT FEEDBACK

Pre-Work was appropriate for the content		Content achieved the learning objectives		Delivery was well-organized		Total # Students
AGREE	DISAGREE	AGREE	DISAGREE	AGREE	DISAGREE	
72% (41/57)	7% (4/57)	72% (41/57)	5% (3/57)	72% (41/57)	7% (4/57)	**TBL 57**
78% (71/91)	6% (6/91)	86% (78/91)	0% (0/91)	87% (79/91)	0% (0/91)	**LGAL 91**
NS	**NS**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	Z-ratio* Probability (p value)

*Statistics calculated www.socscistatistics.com/tests/ztest/default2.aspx
NS – Not Significant

CONCLUSIONS

1. Comparison of the TBL vs LGAL Pedagogies. Based on anonymous student surveys, the data above show that students agreed and disagreed to a similar extent about pre-work. Students seemed to enjoy the content more if the session was an LGAL, as opposed to a TBL ($p<0.05$). A significant difference ($p<0.05$) was also found in the delivery and organization of the session, with LGAL being preferred over TBL.

2. Shifting Content from a TBL to an LGAL. The initial delivery of "Targeted Cancer Therapies" was in a TBL format. Since MCQs covering key foundational knowledge had been written, transition to delivery in an LGAL format was straightforward. For the LGAL, 9 of 10 MCQs were used from the TBL. Addition of slides with complementing factual knowledge and explanations of complex concepts was all that was needed for delivery as an LGAL.

3. Benefits of Active Learning for Medical Students. Students worked in teams, regardless of whether the session was delivered as a TBL or an LGAL. Students adapted and adjusted their behavior to establish functional teams to interpret clinical scenarios and answer challenging questions. Students were able to expand their critical thinking skills while jointly discussing and applying their knowledge with their peers to complete active learning activities.

The Value of the TEAM = <u>T</u>ogether <u>E</u>veryone <u>A</u>chieves <u>M</u>ore