Impact of Team-Based Learning on Concept Mastery and Student Confidence in a High School AP Biology Class

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Abstract: Learning requires student engagement and accountability. Using best practices of flipped classrooms and collaborative learning may not provide desired outputs of student content mastery as shown on assessments. In order to ensure that students are engaged and accountable, specific elements must be embedded into instructional practice. This study looks at the impact of adding the Team-Based Learning (TBL) strategies of readiness assessments and team problems as a structure for classroom instruction for increased student mastery of content and student confidence in their ability as a science learner.

Rationale: As an educator, it is essential that I adapt my practice to ensure that my students are reaching a level of mastery -of the required content. In the past, I have used unit-based instruction and collaborative learning to keep my students actively engaged in the process. However, collaborative and group learning can often not provide essential individual feedback until it is too late and individual students may fail the end of course exam while still passing the course. Because of this, my major focus in pedagogy relates to adapting instruction to minimize the concerns regarding individual accountability in group or collaborative learning. Without a way to clearly identify what each student knows prior to the team portion of the learning; the data may not represent actual learning. Group work, teamwork, and small group activities can become a platform for the "strongest" student in the team to do all the work and the others to potentially not gain anything from even a well-developed task.

Based on the research, Team-Based Learning (TBL) structures are used to successfully provide the high engagement of group learning while also providing a structure for individual accountability and individual readiness assessment. The specific components of the TBL structure includes pre-class preparation, a readiness assessment process, and application activities related to course content. (Michaelsen, 2004; Stein, Colver, & Manning, 2016). The pre-class preparation aligns with the idea of a "flipped" classroom, which has shown benefits to students both academically and motivationally in meta-analyses of multiple studies (Lo & Hew, 2017; Zainuddin & Halili, 2016; Goodwin & Miller, 2013)

One essential element of the TBL class is the necessity for students to be prepared for class and contribute to group discussions. TBL provides a framework for individual accountability for this piece of the flipped classroom through the use of the individual accountability assessment (iRAT) and team accountability assessment (tRAT). These assessments are given to students within the first few minutes of class to assess their understanding of the pre-class assignment and evaluate their readiness for class. "The two parts of the RAP contribute to student preparedness. Specifically, the iRAT provides each student with grade-based incentives to do the assigned readings, and the tRAT provides social incentives to be prepared." (Stein, Colver, & Manning, 2016, p. 30) In some situations, students will have reasons that they were unable to complete the pre-class assignments. Using TBL, students who have not completed the pre-class assignments can still get the value of the material via the group assignment. With the teacher monitoring that this does not become a pattern, the use of group pressure can also add to the potential of these students doing the pre-class assignments more regularly.

The organization of the groups is something that the educator must think critically about, as well. The group structure should be purposely selected to create diversity. For example, groups could be arranged based in interest- with each group including some students who are really interested in the subject and some who might not be (perhaps they were forced to take the course). Groups should be composed of five to seven members for most effective use of TBL (Michaelsen 2004). The groups should also remain stable over time to help build community and to allow for a "wider variety of sanctions, including relatively subtle forms of social pressure that promote accountability" (Olson 1965:60–62).

Based on this information, my research focus is how implementing this TBL structure in my classroom will impact my students' mastery of concepts and confidence in their role as a learner in a science classroom. I am expecting that the implementation of this TBL method will support my current use of a flipped classroom and collaborative learning by providing a structure for individual accountability for the pre-class assignments and also to build a feeling of community in groups.

Intervention: The proposed intervention is to implement TBL strategies embedded into the instructional unit to improve individual accountability instead of unstructured group-work, which has been the trend in past years in my classroom. The intervention will be used in my AP Biology class within a newly designed plant unit which will embed information about plant pathogens. The goals of the intervention are to increase student mastery of the concepts being taught, specifically those related to plant pathogens, and to increase student confidence in the science class due to the conversations between students. In addition, TBL strategies should improve my students' readiness for class and increase the rate at which students complete the pre-classroom assignments. See Appendix I for more details on the placement of TBL strategies within the unit as a whole.

Data collection and analysis: Over the unit, data on student individual readiness assessments (iRAT), student confidence levels in their readiness assessments, team readiness assessments (tRAT), and weekly individual free-response question (FRQ) quizzes will be collected. At the end of the unit, two class periods will be used for student assessment of the learning from the entire unit. The final piece of data to be collected will be a feedback questionnaire to determine students' perception of their confidence from the beginning of the unit until the end and their perceptions of the use of Team-Based Learning (TBL) strategies in the classroom.

The weekly iRAT and tRAT will include 5 questions based on a pre-class assignment. The number of responses correct will be collected as a percentage and labeled as either showing "mastery" (4 or 5 questions correct), showing "emerging" understanding (3 questions correct), or showing that the student is "struggling" (0 to 2 questions correct). The weekly FRQ quiz will be scored on a rubric of 1 – 5 and collected in the "mastery", "emerging", and "struggling" categories. The first week's FRQ will also be used to make a prediction on the final mastery that they student will show on the end of unit

exam. The goal here is to see if over the unit, the student can improve and end the unit with a higher than predicted mastery level.

For the end of unit exams, one of the days will focus on an FRQ test of 4 questions, one which will be a lab-based scenario. The FRQs will be scored using a rubric and students will be able to earn up to 20 points. The number of responses correct will be collected as a percentage and labeled as either showing "mastery" (at or above 80%), showing "emerging" understanding (between 79% and 50%), or showing that the student is "struggling" (below 50%). The multiple-choice exam will also be graded for correctness and data will be reported in percentages using the same scale as the unit FRQ exam.

As the data is added to over the unit, trends will be tracked. Data will be collected in a table and then graphed to show trends. The following questions will be used to analyze the data:

1. Are there patterns and/or growth of student level of mastery?
2. What, if any, comparisons can be made between iRAT scores and end of unit scores?
3. What, if any, comparisons can be made between tRAT scores and end of unit scores?
4. What, if any, comparisons can be made between weekly FRQ quizzes and end of unit scores?
5. What percentage of students felt that their confidence improved throughout the unit?
6. What related feedback did students provide with regards to TBL strategies?

See Appendix IV for more details.

Connections to CATALySES summer institute: During the CATALySES program, we were provided with a workshop from Dr. Wayne McCormack on TBL (Team-Based Learning). This workshop provided an idea for inquiry into instructional practices that provide for better student learning. I am in the process of reading his book on Team Based Learning to ensure that I implement the strategy well and I also am prepared to contact Dr. McCormack using the information he provided, if necessary.

To integrate pathogen connections into my unit, I am also redesigning some of the traditional AP Biology laboratory investigations to include an element related to pathogens:

- AP Biology Transpiration Lab: Students will complete the lab as usual to collect data on the rate of transpiration of plants. Students will then design their own experiment to test the effect of a factor of their choice on the rate of transpiration. As a final piece, students will discuss and formulate hypotheses regarding the causes for symptoms that a plant is showing related to having a situation a fungus invading the vascular system.
- AP Biology Photosynthesis Lab: Students will complete the lab as usual to see how the rate of the floating leaf disks relate to the process of photosynthesis. Students will then used leaves with clear lesions from a pathogen

and test the rate of photosynthesis on those leaves. Students will then make a hypothesis regarding how pathogens can affect the rate of photosynthesis on a plant.

- AP Biology Restriction Enzyme Lab and AP Biology BLAST lab: Students will be provided with a physical sample of a fungus that is invading a plant and have to run PCR and gel electrophoresis on the fungus. Students will be provided with the data from the gel so they can run a BLAST search to formulate a hypothesis about what species of fungus was infecting the plant. Depending on resources, this lab may have to be run as a simulation instead of students actually being able to run PCR and gels in the classroom. In an ideal situation, I will bring my students to the SETS program to run PCR and gels and see if CPET can focus that on a fungus.

In addition, I am contacting the IFAS extension to see if they can do some outreach to help my students understand a little more of the current agricultural issues related to plant pathogens.

Permissions: Describe any permissions that you need to implement your action research project (principal, parents, etc.)

Works Cited/Resources

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Appendix I: AP Biology Daily Instruction Plan

DAY 1 - Prior to class: Reading on plant parts and basics of plant processes - **iRAT w/confidence levels** (5 min.) - **tRAT** (10 min.) - **Lecture** on plant parts and plant processes with students creating diagrams/concept maps	DAY 2: - **Hands-on Activity:** Stomata peel - **Instructional Activity:** Homeostasis of Water in Plants	DAY 3: - **Stomata situation (TBL "Significant Problem"):** Are plants more likely to get bacterial infections in moist/hot environments?	DAY 4: - **Instructional Activity**: Plant vascular systems and their role in transpiration and photosynthesis	DAY 5: - **AP LAB: Transpiration** with embedded content information - **End of week FRQ quiz**
DAY 6: - Prior to class: Reading on transpiration, photosynthesis, and pathogens - **iRAT w/confidence levels** (5 min.) - **tRAT** (10 min.) - **AP LAB: Transpiration**	DAY 7: - **AP LAB: Transpiration** with embedded content information	DAY 8: - **Vascular System situation (TBL "Significant Problem"):** What is causing the plant to wilt? (connect to pathogen)	DAY 9: - **Instructional Activity**: Modeling photosynthesis in plants	DAY 10: - **Instructional Activity**: Modeling photosynthesis in plants - **End of week FRQ quiz**
DAY 11: - Prior to class: Reading on photosynthesis - **iRAT w/confidence levels** (5 min.) - **tRAT** (10 min.) - Quick **lecture** on photosynthesis and redox reactions	DAY 12: - **AP LAB: Photosynthesis leaf punch** with embedded content information	DAY 13: - **AP LAB: Photosynthesis leaf punch** with embedded content information	DAY 14: - **AP LAB: Photosynthesis leaf punch** – Adapt to evaluate the effect of photosynthesis on plants infected w/ visible bacterial lesions	DAY 15: - **Instructional Activity:** What is the pathogen? - **End of week FRQ quiz**
DAY 16: - Prior to class: Reading on Central Dogma, PCR, gel electrophoresis - **iRAT w/confidence levels** (5 min.) - **tRAT** (10 min.) - Quick **lecture** on Central Dogma, PCR, gel electrophoresis	DAY 17: - **AP LAB: Restriction Enzymes**- Determine the pathogen based on DNA (maybe modeled and not actual DNA)	DAY 18: - **Central Dogma situation (TBL "Significant Problem"):** Some problem situation related to errors or issues in the processes of transcription and translation	DAY 19: - **AP LAB: Restriction Enzymes**- Determine the pathogen based on DNA (maybe modeled and not actual DNA)	DAY 20: - **AP LAB: Restriction Enzymes**- Determine the pathogen based on DNA (maybe modeled and not actual DNA) - **End of week FRQ quiz**
DAY 21: - Prior to class: Reading on sequencing genomes, bioinformatics - **iRAT w/confidence levels** (5 min.) - **tRAT** (10 min.) - Quick **lecture** on sequencing genomes, bioinformatics	DAY 22: - **AP LAB: BLAST**- Determine the pathogen based on DNA	DAY 23: - **AP LAB: BLAST**- Determine the pathogen based on DNA	DAY 24: **End of Unit Test- FRQs**	DAY 25: **End of Unit Test- Multiple Choice**

Additional Ideas: - Ascospore lab- genetics of asci with connection to fungal infections in plants

Appendix II: Unit Plan
Title:
Key Question(s):
Science Subject: AP Biology
Grade and Ability Level: AP Biology (9 – 12 grade)
Science Concepts:
Overall Time Estimate:

Appendix II: Readiness Assessments

Appendix IV: Data Collection and Analysis Plan

DATA COLLECTED	METHOD OF SCORING	ANALYSIS
DAY 1 - **iRAT w/confidence levels** - **tRAT**	* Score for percentage correct- 100% and 80% - Mastery 60%- Emerging 40%, 20%, 0% - Struggling *Collect confidence level data	*Compare individual scores with team scores
DAY 5 - **End of week FRQ quiz**	*Score using rubric from 1 – 5 5 – Mastery 4 or 3- Emerging 1 or 2- Struggling	* Compare student iRAT and tRAT scores to FRQ scores *Make predictions of final unit exam mastery based on data
DAY 6, 11, 16, 21 - **iRAT w/confidence levels** - **tRAT**	* Score for percentage correct- 100% and 80% - Mastery 60%- Emerging 40%, 20%, 0% - Struggling	*Compare individual scores with team scores * Compare previous iRAT and tRAT scores to new scores - Are more students scoring mastery in iRAT than previously? - Is there a change in confidence levels of students from previously collected data? - Are more teams scoring mastery on tRAT than previously?
DAY 10, 15, 20 - **End of week FRQ quiz**	*Score using rubric from 1 – 5 5 – Mastery 4 or 3- Emerging 1 or 2- Struggling	*Compare previous FRQ mastery to this week's FRQ mastery * Align student iRAT and tRAT scores to FRQ scores
DAY 24 **- End of Unit Test- FRQs**	* Score using rubrics (20 points)- At or greater than 80% - Mastery 79% - 50%- Emerging Lower than 50% - Struggling	* Align all data in charts and graph- are there patterns with: - Level of mastery? - iRAT scores and end of unit scores? - tRAT scores and end of unit scores? - Weekly FRQ quizzes and end of unit scores? - Are other patterns noticeable?
DAY 25 **- End of Unit Test- Multiple choice**	* Score for percentage correct- At or greater than 80% - Mastery 79% - 50%- Emerging Lower than 50% - Struggling	
DAY 25 **- Feedback form**	* Collect data on: - student perception of their confidence from the beginning to the end of the unit - student thoughts/feelings on Team Based Learning	* Collect for anecdotal evidence

Notes for Valerie
Virtual Gel electrophoresis - http://learn.genetics.utah.edu/content/labs/gel/ ;
Virtual antibacterial lab- https://www.classzone.com/books/hs/ca/sc/bio_07/virtual_labs/virtualLabs.html
Virtual bacterial transformation lab- https://www.classzone.com/books/hs/ca/sc/bio_07/virtual_labs/virtualLabs.html
(focused on insulin)

ClassZone index- https://www.classzone.com/books/hs/ca/sc/bio_07/labs.cfm

Good info: http://www.davidmoore.org.uk/21st_Century_Guidebook_to_Fungi_PLATINUM/Ch14_11.htm

SC.912.L.14.7 - Relate the structure of each of the major plant organs and tissues to physiological processes. (Content Complexity Level 2)

- explain how the structures of plant tissues and organs are directly related to their roles in physiological processes
- explain the function of plant tissues and organs in the context of physiological processes
- describe specific functions of structures within organs or tissues in isolation
- relate the structure of plant organs to their physiological process
    - specific organs are limited to: roots, stems, leaves, flowers, fruits, and cones
    - specific physiological processes should be limited to photosynthesis, cellular respiration, transpiration, growth, and reproduction
- relate the structure of plant tissues to their physiological function
    - specific tissues are limited to: meristematic, ground, dermal, and vascular
    - specific physiological processes should be limited to photosynthesis, cellular respiration, transpiration, growth, and reproduction
- relate specific plant structures to their physiological function.
    - specific structures are limited to: cambium, guard cells, phloem, root hairs, root cap, seed, stomata, xylem, stamen, pistil, ovary, petals, sperm, egg, sepal, filament, anther, style, stigma
    - specific physiological processes should be limited to photosynthesis, cellular respiration, transpiration, growth, and reproduction

Basic Plant Pathology- https://mrec.ifas.ufl.edu/lso/SCOUT/Plant%20Pathology.htm

CITE- https://www.cambridge.org/core/journals/plant-genetic-resources/article/diseases-of-medicinal-and-aromatic-plants-their-biological-impact-and-management/3E49338DEAC2D7AF3A76E6880620195F/core-reader

Teachers will present their **action research proposals** in a Powerpoint format at the end of the two week institute on Friday, June 29, 2018. Teachers will then present the findings from their interventions at the annual JSEHS, which takes place in January 28 – 3, 2018 (you are only required to be there Monday, although you are certainly welcome to stay for the student presentations on Tuesday). In addition, teachers are encouraged to present their work at school, district, and professional meeting settings and in relevant professional publications. emack47@cpet.ufl.edu

Draft action proposals must be submitted to Canvas/E-Learning site by Friday, June 29, 2018. The lesson plan drafts should be submitted along with the draft proposal. Draft action proposals will be reviewed and any comments will be added to Canvas for consideration during final proposal preparation.

Final action proposals and lesson plans are due Friday, August 3, 2018, and should be submitted on Canvas.