

An Investigation of the Effects of integrating Team-based Learning into the Honors Biology Genetics Unit
on Student Achievement

Patrick Kelly
Biology/AP Physics Teacher
Leesburg High School
Lake County Schools
kellyp@lake.k12.fl.us

Abstract:

Team-based Learning (TBL) is a learning system developed by Dr. Larry Michaelsen. It incorporates many elements of evidence-based teaching and stresses the application of information learned during a course. Studies have been conducted on the efficacy of TBL in the professional school setting but not in secondary schools. This study will attempt to determine the effects of implementing Team-based Learning modules on the content mastery of students during the Genetics unit. Classes will be grouped into those receiving TBL and those that are not. Pre and post test data will be collected and statistical tests will be applied to determine if TBL implementation had a significant impact on student learning.

Rationale:

Instruction in public school was designed to properly train factory workers as evidenced by the traditional lecture class with students in rows with the teacher transferring knowledge and skill through direct instruction. There is little to no cooperative discussion and while some students are gaining knowledge, not all students are. Problems in industry are not solved by individuals but by teams of professionals with varying backgrounds through open discussion and team meetings.

This paradigm shift is also occurring in the sciences with research responsibilities transitioning from an individual to a team effort. A story posted on *Wired* discusses two research teams that each had the same problem. During the experiment, the protein that was being synthesized was adhering to the filter so measurement was impossible. One team consisted of *E. coli* specialists while the other was comprised of geneticists, biochemists, molecular biologists and medical students. The first team of the *E. coli* experts synthesized multiple solutions and tested them over many weeks. Eventually a fix was discovered but the process was time consuming and inefficient. The other team had no protein experts so each member was able to contribute ideas equally. Within 10 min of reciprocating ideas amongst each other the problem was solved. Transcripts of the meeting revealed that the diversified team lacked a common language and were forced to rely on analogies and encouraged the members to reconsider

assumptions (Lehrer, 2009). Dr. Kevin Dunbar terms this “distributed reasoning.” The study highlighted that while “distributed reasoning” is usually beneficial it will be ineffective if the team members have too similar a background as they will have the same solutions or if the teams are too diverse and have different goals (Dunbar, 2000). Students in high school must be taught how to function properly as a team and make progress towards goals.

Team based learning (TBL) is a cooperative structure that creates a group of diverse students and tasks them with solving authentic, relevant problems. So far there have been no reported studies on the application or effectiveness of TBL in the secondary school setting. Many professional schools (medical, business, nursing & pharmacy) have adopted the approach with positive results. Empirical studies have shown increased test performance, outlooks on group work and attendance/engagement. TBL also encompasses many of the 6 best practices of evidence based teaching as described by Petty such as feedback and concept-driven decisions (Michaelson, 2011).

Implementation of the strategies will be challenging as students will have had little to no exposure to this type of learning. As discussed in the article “Time to Adjust” students have been conditioned to be passive learners and will resist being an active member of the process. While initial perceptions are most likely to be negative it is important to continue the implementation as the study showed increased gains after the second year of implementation (Mennenga, 2015).

Severiens, Knipples van Mil, and Ten Dam (2010) stated that learning modules should stimulate active learning, use authentic tasks and stimulate reflection. TBL directly addresses these elements. Students must come with a certain mastery of the material, apply the material to solve real-world problems and then during the intergroup discussion students are able to reflect the reasoning behind their answer choice.

This study will investigate the effects of team based learning implementation on content mastery measured by assessment data during the genetics unit.

Implementation:

Team-based learning (TBL) has been shown to be effective in the professional school setting (Michaelson, 2011). TBL consists of four main elements: Strategically formed, permanent teams, readiness assurance, 4-S application activities and peer feedback. Teams should be permanent to increase the chances of better cooperation and interdependence. Readiness assurance is a four step process to ensure students have the content knowledge to use during the application activities. Students will be assigned a pre-reading to read before class. In class students will be given an individual readiness assurance test (iRAT). The iRAT will consist of 5-10 multiple choice questions testing concepts in the pre-reading material. The next phase is the team readiness assurance test (tRAT). Students will complete the same multiple choice assessment in their groups using immediate feedback assessment technique (IF-AT) cards. In 99% of the trials, tRAT scores averaged higher than the highest iRAT score. The fourth step is the appeals process where students may appeal to the instructor if they believe their answer is correct and must cite evidence from the prereading materials. After the readiness assurance process (RAP), the teacher can use the results from the RATs to determine if there are any conceptual deficiencies that could be corrected with a short discussion or lecture.

The third stage is the 4-S application. Students will be assigned to answer a **significant** problem either through a scenario with multiple choice questions or through the creation of a product such as a graphic organizer. Students will be tasked with making a **specific** choice among questions with other likely answers. Each group will work on the **same** problem so groups will be able to learn from each other's rationale. Students will report their answers **simultaneously** using cards or whiteboards. The groups will then discuss the basis for their choice of answer using concepts learned earlier.

The final stage is peer evaluation. Students must not only be accountable to themselves but to the other members in the group. Each member of the group must provide constructive feedback concerning the other members. The instructor knows who provided individual feedback however the students do not so honest negative feedback is more likely if warranted.

The study will be conducted in Honors Biology classes. Two classes will be taught incorporating TBL while others taught by different instructors will serve as the control. Within the first few weeks of school, teams of 4-5 students will be created during class time based on factors such as gender and content knowledge. The teams will stay together for the rest of the year during TBL activities to foster cooperation amongst the members. TBL principles will be implemented in phases beginning with the 4-S phase towards the beginning of the year. More elements will be added with a full implementation by the Genetics unit in December. The main focus of the study will be conducted during this Genetics unit. The three week unit will consist of traditional lessons including a Gel Electrophoresis (Nature's dice activity) with a pedigree creation. The unit will culminate with the TBL module.

Connection to Bench to Bedside:

Team-based learning modules were covered by Dr. Wayne McCormack. "Modes of Inheritance (Nature's Dice)" was an activity during the institute. E-gel equipment will be provided by the CPET staff.

Data Collection:

Four classes will be divided into two groups. Two will form the experimental group consisting of TBL implementation and two will serve as the control. All students will take a pretest concerning genetics. After completion of the unit, a post assessment will be given. Students will be de-identified after the pairing process. A standard t-test will be used to compare the post test data from the experimental group receiving TBL and the control group. A paired t-test will be used to compare pre and posttest from the experimental group. If the p values from either test is less than 0.05 then the results can be said to be significant.

Literature Cited:

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Klop, T, Severiens, S. E, Knippels, P. J. M, van Mil, M. & Ten Dam, T. M. G (2010): Effects of a Science Education Module on Attitudes towards Modern Biotechnology of Secondary School Students. *International Journal of Science Education*. 32:9, 1127-1150

Lehrer, J. (Ed.). (2009, December 21). Accept Defeat: The Neuroscience of Screwing Up. Retrieved June 25, 2015, from http://www.wired.com/2009/12/fail_accept_defeat/

Mennenga, H. (2015). Time to Adjust. *Nurse Educator*, 40(2), 75-78.

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Budget:

2 E-Gel® Agarose Gels with SYBR Safe™ DNA Gel Stain Starter Kit, 1.2% #G6206-01 \$133 each=
\$266

DNA markers/enzymes will be provided by CPET

Carolina DNA and Marker Only refill Item # 211018C \$115

Permissions:

Principal and district staff will be made aware of the study.

SINGLE LESSON PLAN

Teacher: Patrick Kelly

Content Area/Grade: Honors Bio

Date:

Unit Name: Genetics

Unit Goal

What unit goal does this daily lesson address?

Students will be able to describe the process of gene inheritance through Medelian and Non-Mendelian mechanisms

Standard(s)/Benchmark(s)

What standard(s)/benchmark(s) does this daily lesson address?

SC.912.L.16.1

Students will understand that...

What should the students understand by the end of today's lesson?

- Traits are inherited through units called genes
- Alleles can either be dominant or recessive
- Gel Electrophoresis can be used to determine what alleles are present in a person
- Pedigrees can be analyzed to determine the mode of inheritance

Essential Questions

What essential question(s) does this lesson address?

How are genes passed from parent to offspring?

Connecting Concepts

How will you review yesterday's content and connect today's lesson to it?

Bellringer question on dominant vs recessive traits. Discuss how we can use biotech equipment to determine a persons genotype.

Organizing Students for Learning

How will students be organized today for the lessons activities?

Students will be organized in their standard seating groups

LEARNING EXPERIENCES, INSTRUCTION AND RESOURCES

What activities or experiences (from your Unit Plan) will students engage in today?

Lesson Sequence

Activating Prior Knowledge

Bellringer question/Class discussion about dominant vs recessive traits and phenotypes vs genotypes

- ABC Brainstorming
- KWL
- Anticipation Guide
- Card Sort
- Think-Pair-Share

Explicit Instruction

Brief lecture/demonstration about what Gel Electrophoresis is and how to run the gel

- Motivational Hook
- Lecture
- Demonstration
- Note-taking Guide

Lesson Sequence			Resources and Materials
Group Processing of New Information	Students will prepare samples of the DNA with restriction enzymes and load the gels using micropipettes.	<input type="checkbox"/> Jigsaw <input type="checkbox"/> Reciprocal Teaching <input checked="" type="checkbox"/> Concept Attainment <input type="checkbox"/> Think-Pair-Share	<input type="checkbox"/> Lab / Inquiry Activity <input checked="" type="checkbox"/> Computer <input checked="" type="checkbox"/> LCD Projector <input type="checkbox"/> Paper <input type="checkbox"/> Pencils <input type="checkbox"/> Whiteboards <input type="checkbox"/> Markers <input type="checkbox"/> Butcher Paper <input checked="" type="checkbox"/> Response Cards <input type="checkbox"/> Post-it Notes <input type="checkbox"/> Video Clip(s): <input type="checkbox"/> Website(s): <input checked="" type="checkbox"/> Lab Materials: 1. Nature's Dice from Carolina
Elaborative Questioning	Students answer questions in the lab instructions packet	<input type="checkbox"/> Inferential Questions <input checked="" type="checkbox"/> Analytic Questions <input type="checkbox"/> Philosophical Chairs	
Demonstrating Understanding	Students report results of their gel to the class and the fill in the pedigree. Answer analysis questions at end of lab	<input type="checkbox"/> Graphic Organizers <input type="checkbox"/> Picture Notes <input type="checkbox"/> Flow Charts <input type="checkbox"/> Concept Maps <input type="checkbox"/> Mnemonics <input type="checkbox"/> Graffiti	
Reflection	Have class discussion concerning the observations they made and any possible irregularities in the pedigree	<input type="checkbox"/> Reflective Journals <input type="checkbox"/> Think Logs <input type="checkbox"/> Exit Ticket (Student Learning)	
Daily Progress Monitoring Assessment	Answers to analysis questions	<input type="checkbox"/> Quiz <input type="checkbox"/> Journal <input type="checkbox"/> Exit Ticket (for Content) <input type="checkbox"/> Response Cards	
Based in the results from your Daily Progress Monitoring Assessment, what concepts need to be revisited in the next lesson?			Homework



Leesburg High School Science Learning Scale

GRADE /CONTENT: 9-10 Biology _____ NGSS: SC.912.L.16.1 _____

Learning Goal: Students will be able to describe the process of gene inheritance through Medelian and Non-Mendelian mechanisms

Score 4.0	Students I/will <i>No major errors regarding the score 4.0 content</i> – <ul style="list-style-type: none">• I can design an experiment to determine whether two genes are linked• I can create a pedigree of my own family
Score 3.0	Students I/ will <i>No major errors regarding the score 3.0 content</i> – <ul style="list-style-type: none">• I can calculate the probability of certain genotypes or phenotypes using a Punnett Square• I can explain how Mendel's laws are applied in a Punnett square.• I can analyze a pedigree to determine a trait's mode of inheritance• I can analyze test crosses to predict the probability of offspring having certain genetic disorders
Score 2.0	Students I/ will <i>No major errors regarding the score 2.0 content</i> <ul style="list-style-type: none">• I can determine where to place the alleles on a Punnett square• I can describe how to read a pedigree
Score 1.0	With help, partial success at score 1.0 content <ul style="list-style-type: none">• I can define allele, gene, homozygous and heterozygous• I can define sex-linked, codominance and incomplete dominance
Score 0.0	Even with help, no success - <ul style="list-style-type: none">• My parents have type O blood and mine is AB...

UNIT PLAN

Unit Title: Genetics

Content Area/Grade: Honors Bio

Teacher: Patrick Kelly

Implementation Time Frame: 3 weeks

STAGE 1: THE DESIRED RESULTS

What are my learning goals?

Unit Goal

Students will understand that...

Standard(s)/Benchmark(s)

What standard(s)/benchmark(s) does this daily lesson address?

Students will be able to describe the process of gene inheritance through Mendelian and Non-Mendelian mechanisms

SC.912.16.1

Related Misconceptions

What misconceptions are predictable?

Students will know...

Vocabulary, terminology, definitions

- All mutations are harmful
- Single gene codes for most traits
- Dominant traits are always most common in population

Vocabulary

- Genetics
- Genes
- Allele
- Recessive
- Dominant
- Codominant
- Sex-linked
- Homozygous
- Heterozygous
- Punnett Square
- Incomplete Dominance

Essential Questions

What questions will foster inquiry, understanding and transfer of learning?

- How did Mendel's experiments shape the science of genetics?
- How do math and probability relate to science and genetics?

Students will know...

key facts, formulas, critical details, important events, important people, timelines

- You need to know how to use Mendel's laws of segregation and independent assortment to analyze patterns of inheritance.
- You need to know how dominant, recessive, codominant, sex-linked, polygenic, and multiple allele modes of inheritance cause observed inheritance patterns.

Students will be able to...

Specific skills students will acquire as a result of this unit

- Use Punnett squares to solve problems.
- Analyze pedigrees to determine mode of inheritance
- Use Gel Electrophoresis equipment

STAGE 2: ASSESSMENT EVIDENCE

What evidence will show that my students have achieved the learning goals?

Performance tasks:

Through what specific “real-world” performance task(s) will students demonstrate their understanding of the learning goals?

- Proper use and analysis during Gel Electrophoresis activity
- Answers/rationale behind choices during Team-based learning module

Rubric

By what criteria will “performance of understanding” be judged?

See scale

Other Evidence:

What other evidence needs to be collected in order to monitor student progress on these concepts and skills along the way?

Quiz data

Self-Assessment/Reflection

How will students reflect and self-assess their learning?

Students will evaluate themselves on the learning scale and explain why they rated themselves as they did.

STAGE 3: LEARNING EXPERIENCES, INSTRUCTION, AND RESOURCES

What activities will help my students achieve the learning goals?

<p>What here</p>	<p>What is expected? How will you ensure that students are aware of the learning goals? Where are your students? How will you establish your students' prior knowledge?</p> <p>Students are expected to meet the learning goal. I will remind students daily of the learning goal and the scale with the goal will be on their tables. I will establish prior knowledge through a classroom discussions</p>
<p>Hook old</p>	<p>How will you hook students at the beginning of the unit? How will you hold their attention throughout the units?</p> <p>I will use PTC test paper and discuss why some students can/cannot taste the paper. Throughout the unit I will hold their attention through lessons such as dragon genetics, the gel electrophoresis and the TBL module at the end</p>
<p>Experience xplore quip</p>	<p>What critical input experience will help students explore the key ideas and essential questions? How will you equip your students with needed skills and knowledge?</p> <p>The gel electrophoresis (Nature's Dice) and TBL module are the most important. I will review and demo how to run a gel and remind students of how to behave during a TBL session.</p>
<p>Reflect ethink ehearsing evising efining</p>	<p>How will you encourage students to reflect and rethink? How will you guide students in the process of rehearsing, revising, and refining their work?</p> <p>Students will have to complete the tRAT during the TBL module where they will be forced to reflect on their personal answer and most likely rethink with the input of others. I will monitor the room during the session and ask them to explain their rationale.</p>
<p>Exhibit valuate</p>	<p>How will you help students to exhibit and self-evaluate their developing skills, knowledge and understanding throughout the unit?</p> <p>We will discuss solutions to problems in class.</p>
<p>Tailor</p>	<p>How will you tailor your instruction to meet the different needs, interests and abilities of all learners in your classroom?</p> <p>Groups will be formed heterogeneously. Lessons will incorporate activities from quick note taking to hands on wet labs.</p>
<p>Organize</p>	<p>How will you organize and sequence the learning activities to maximize the engagement and achievement of all students?</p> <p>We will discuss simple Mendelian genetics first and have students practice those skills. We will then move onto more complex patterns of inheritance such as sex-linked.</p>

Big Idea:		Standard(s)/Benchmark(s):
Unit:		Sample Activities
Grade:		
Score 4.0	In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.	
Score 3.0	<p>The student:</p> <p>The student exhibits no major errors or omissions</p>	
Score 2.0	<p>There are no major errors or omissions regarding the simpler details and processes as the student:</p> <ul style="list-style-type: none"> • Recognizes or recalls specific terminology • Performs basic processes, such as: <p>However, the student exhibits major errors or omissions regarding the more complex ideas and processes</p>	
Score 1.0	With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.	
Score 0.0	Even with help, no understanding or skills demonstrated.	