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

Patrick Kelly

Honors Biology/AP Physics/AP Calculus 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 evolution unit. Pre and posttest data will be collected and used 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 evolution 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 s**pecific** 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. 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 evolution unit in February. The main focus of the study will be conducted during this evolution unit. The three week unit will consist of traditional lessons and a TBL module and will incorporate emerging pathogen themes.

Connection to CATALySES:

Team-based learning modules were covered by Dr. Wayne McCormack. The basis of the module will consist of the growing threat of antibiotic resistance in various bacteria species.

Data Collection:

All students in three sections of Honors Biology (~60 students) will take a pretest concerning evolution. After completion of the unit, a post assessment will be given. Students will be de-identified after the pairing process. 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:

Dunbar, K. (2000). How Scientists Think in the Real World. *Journal of Applied Developmental Psychology, 21*(1), 49-58. doi:10.1016/S0193-3973(99)00050-7

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. doi:10.1097/NNE.0000000000000116

Michaelsen, L., & Sweet, M. (2011). Team-based learning. *New Directions for Teaching and Learning, 2011*(128), 41-51. doi:10.1002/tl.467

Permissions:

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

Antibiotic Resistance TBL Application

Adapted from *What is Resistance to Antibiotics Activity* https://tinyurl.com/gro748f

You are infected with a bacterial disease. Your brother had this same disease last month, and took a full course of antibiotics. He quickly became better. You were prescribed the same antibiotic, but they had no effect. In fact, you had to return to the doctor after a week, because your condition did not improve. What has happened? Why did you remain sick after taking antibiotics, while your brother quickly recovered? There are three possible hypotheses:

A) you developed a tolerance for the antibiotic (i.e. you experienced a non-genetic change that made you less sensitive to the effects of the antibiotic).

B) the bacteria infecting you developed a tolerance for the antibiotic (i.e. individual bacteria experienced a non-genetic change that made them less sensitive to the effects of the antibiotic).

C) the bacteria infecting you evolved to be resistant to the antibiotic (i.e. a genetic mutation for resistance occurred in a bacterial cell, it had a reproductive advantage and increased in the population).

1. **Which hypothesis (A, B, or C) do you think is most likely?**

When you first visited your doctor, she told you that she is conducting research on antibiotics, and asked you to be a part of the study. You agree. As part of the study, you go to the doctor every day and let her take a new sample from your infection, which she then conducts tests on. She discovered that on the first day, your bacteria were susceptible to the antibiotic (i.e. the bacteria were killed by the antibiotic). She then prescribed the antibiotic to you, which you immediately began taking. Later in the week, the bacteria from your infection were found to be resistant to the antibiotic (i.e. the bacteria were not killed by the antibiotic).

2. **This result rules out which of the three hypotheses (A, B, or C)?**

Another result from the study is that initially, all the bacteria were susceptible to the antibiotic, but by the third day, some of the bacteria were resistant to the antibiotic. With each passing day, more of the bacteria were resistant, until finally all of the bacteria were resistant.

3. **Which hypothesis does this result support?**

Bacterial resistance to antibiotics is a global crisis. Diverse resistance strategies have been developed within bacterial population ranging from pumps to remove antibiotics from the cell to exchanging genes that code for enzymes that breakdown antibiotics to developing point mutations in certain proteins or ribosomal subunits rendering the antibiotic useless. For this discussion, we will stick to only the point mutation model of antibiotic resistance. The quinolone class of antibiotics acts to prevent DNA replication. For bacteria to replicate their DNA, they need to separate the strands of DNA from each other. Two key enzymes help accomplish this task: DNA gyrase (gyrA) and topoisomerase IV (parC).

4. Here are the original and mutated sequences for parC:

Original: CATGGCGATAGCGCGTGCTATGAAGCG

Mutated: CATGGCGATCTGGCGTGCTATAAAGCG

For each transcribe and translate into the amino acid sequence and circle the difference in the amino acid sequences.

Which of the following best explains why these changes result in antibiotic resistance?

a. Changing the amino acid renders the parC enzyme non-functional
b. Changing the amino acid slightly changes the shape of the parC enzyme and prevents the antibiotic from binding to it.
c. Changing the nucleotide sequence would cause less parC enzyme to be created and therefore the antibiotic would have less target to bind
d. Changing the amino acid sequence adds an additional function to the parC enzyme allowing it to degrade the quinolone antibiotics

5. **Place the following events in order:**
    i. Exposure to antibiotics
    ii. Antibiotic resistant bacteria survive and reproduce
    iii. Random DNA mutations

    a. i, ii, iii
    b. iii, i, ii
    c. i, iii, ii
    d. ii, i, iii

6. **Draw a series of images showing the progression of antibiotic resistance within a population of bacteria.**
7. **How does antibiotic resistance of bacteria demonstrate various principles of evolution? Make sure to use and underline the following terms in context: selection, mutation, adaptation, bottleneck, fitness, and allele. Limit your responses to one short paragraph.**