

THE EFFECTS OF TEAM-BASED LEARNING ON
STUDENT ACHIEVEMENT IN SCIENCE

by

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ABSTRACT

Student preparedness for a global and increasingly dynamic future is used as a lens to gauge teachers' effectiveness in the classroom. Collaboration fostering 21st century skills is reviewed, with the importance on student engagement, critical thinking, habits of learning, and making students' thinking visible through dialogue. The teachers' role in facilitating collaborative learning can make the experience a tremendous success or, if done incorrectly, can lead to worse results than teacher-focused lectures. Studies have shown that student discourse that focuses on thinking, explanations, and possible solutions are paramount to deeper, more meaningful learning; collaboration is ineffective when student discussion is fixed to answers. Team-based learning with frequent low-stake quizzes has been found to increase student comprehension. The time it takes students to receive the feedback is paramount to the effectiveness of the quizzes. It's argued that for team-based learning to be effective, there must be a high level of student accountability and meaningful group rewards. Students will allow others to do their work for them if allowed, and the group effort, both on quizzes and in other activities, should be seen as a reward of the individual's effort.

INTRODUCTION AND BACKGROUND

I teach 8th grade physical science at Cardigan Mountain School. CMS is a junior boarding school located in Canaan, New Hampshire. The school enrolls 214 students, with 195 boarding students and 19 day students. Our student population is made up of 35% international students. The majority of our international students come from China, South Korea, and Mexico. Our 6th and 7th grades are fairly small (15 and 30 students, respectively) with our 8th and 9th grades comprising the bulk of the student population (170 students). The international students come with a wide range of English fluency. Those needing support are placed in ESL class. The majority of the Cardigan's students come from affluent families whose parents are deeply committed to their child's academic success. The 8th grade science curriculum is based on CPO Science-Foundation of Physical Science. The instruction is student-centered with weekly investigations, varied summative assessments, periodic lectures, and a capstone PBL at the end of each trimester. The scope and sequence includes measurement, motion, energy, simple machines, atomic structure, chemical reactions, gas laws, and electricity & magnetism.

This classroom research project investigates the effects of team-based learning on student achievement in science. Small groups of students work collaboratively with the goal of teaching and learning together. Students will be assigned a group for an entire unit. The groups will help each other on classwork, homework, labs, and preparing for exams. A biweekly quiz will be given to each group. This quiz will be based on the previous days' work; it will be taken individually and then as a team, with each student receiving a score for both efforts. The latter quiz will give students the opportunity to

exchange possible solutions to the questions and learn from their peers. The team-based approach to learning and taking quizzes will be analyzed to see if it has an impact on the students' overall comprehension of the material, engagement in science, and effect on students' exam grades.

The following research questions will lead the classroom research project:

1. Does team-based learning improve students' comprehension?
2. Will students teach and learn from their peers in a team-based classroom?
3. Is student engagement improved with use of team-based learning?

CONCEPTUAL FRAMEWORK

Student achievement, comprehension, and readiness in science are a concern for teachers, students, and families all across the country. While student competency has improved slightly over the past ten years, there is a great concern that our students are falling behind when compared to other nations; in science, the US ranked 27th out of 64 countries (Desliver, 2015). The government has pushed through various initiatives to enhance student achievement, however, few of them have met the desired outcome. As students prepare for careers in a global workforce that are increasingly focused on science, technology, engineering and mathematics, there needs to be improved instruction and more meaningful learning.

Team-based learning and student collaboration are effective teaching methods that foster 21st century skills and career readiness. Effective peer-to-peer communication is paramount as students prepare for a dynamic and unpredictable future. There is tremendous value with students working in groups, problem solving, and learning as a community. According to Dueck (2014), "Group projects instill and enforce many

qualities that are critical to success in future endeavors, including communication, group organization, consensus, and compromise” (p. 157). Teachers need to embrace collaboration as a way of engaging conversation, making thinking visible, and broadening the students’ view of intelligence. Sir Ken Robinson notes that this is one of the great skills we have to promote and teach—collaborating and benefiting from diversity rather than promoting homogeneity (Azzam, 2009).

Today’s classrooms should no longer be designed on the industrial model of education. Teacher-focused learning, with students acting as repositories of information, is not meeting the needs of today’s learners. This outdated approach, with students moving from classroom to classroom and absorbing discrete chunks of information, still dominates in many of our schools’ classrooms (Wolfe, Steinberg, Hoffman, 2013). Moving to a constructivist approach, with students working collaboratively, making interdisciplinary connections, and playing the role of both teacher and learner, will help transform our educational system and better prepare our students. “There is nothing dramatically new in constructivism: the core ideas expressed by it have been clearly enunciated by John Dewey among others, but there is a new, widespread acceptance of this old set of ideas, and new research in cognitive psychology to support it” (Hein, 1991. p. 1).

Collaboration is a cornerstone for students making connections with their peers, developing a deeper understanding of the material, fostering habits of learning, and constructing their own view of education. A greater emphasis needs to be placed on students becoming active and engaged participants, instead of passive learners of fleeting information.

The potential for higher-order learning increases further when individuals work with peers. Dozens of studies of afterschool learning point to the importance of various forms of collaborative learning. Collaboration often requires greater levels of energy and attention to detail, and small-group problem solving sessions also can require more of learning. They can hear a variety of perspectives and strategies, refine their thinking, and justify their ideas to others- just as in real-life collaborations. In doing so, they are more likely to persist in a trajectory from novice to apprentice to expert. (Wolfe et al., 2013. p. 134)

While research has determined student collaboration is an effective teaching method, the teacher's role in facilitation determines the quality of collaboration and the depth of student learning. "Both theoretical and empirical literature supports the power of giving explanations compared to other kinds of participation such as giving answers. Researchers theorize that giving explanations to others promotes learning by encouraging the explainer to reorganize and clarify material, to recognize misconceptions, to fill in gaps in her own understanding, to internalize and acquire new strategies and knowledge, and to develop new perspectives and understanding" (Webb, N., Franke, M., Ing, M., Chan, A., De, T., Freund, D., Battey, D. (2008). p. 361). The process the students go through in articulating their thoughts, defending their opinions, and teaching their peers leads to better comprehension of the material. Student-to-student discourse that focuses solely on the answers leads to no additional student learning (Webb et al., 2008).

Team-based learning and collaboration--with students teaching and learning from one another--can be enhanced with frequent, low-stakes assessments. The impact of periodic quizzes on students' comprehension has been well documented. According to

McDaniel, Agarwal, Huesler, McDermott, Roediger, H. (2011), the frequent, low-stakes quizzes produced gains in students' unit exams; the improvements ranged from 13% to 25%. The benefits of frequent quizzing also showed an improvement in mid-year and year-end examinations. Students construct new meaning and connections to the material presented in class. The use of frequent quizzes allows for students to gauge their understanding and receive the necessary assistance from their peers and teachers, which results in greater comprehension and fewer ingrained.

Frequent quizzing has been shown to make material "stickier." Incorporating frequent, low-stake quizzes improves student retention by making them active and critical learners (Brown, 2014). Frequent quizzing reduces student anxiety by normalizing the experience; this strategy also puts students in control of their learning by gauging their comprehension and making necessary adjustments to their studying and summative test preparation. In a study done by Cranney, Mihyun, McKinnon, Morris, Watts, (2009), a group of university students completed a unit on psychobiology. There were three phases: (phase one) psychobiology video, (phase two) video related activities, (phase three) and an unplanned exam. Students in phase two were broken up into three groups. One group was given a quiz to complete as a team, one group was given the same quiz to take individually, and the last group did not take the quiz. The students' achievement on the summative exam (phase three) was compared to their task during phase two. Those students who took the quiz individually scored higher on the exam than those students who didn't take a quiz. The students who took a group quiz fared the best by scoring the highest marks on the phase-three exam.

Grades and feedback students receive on quizzes has a tremendous impact on the assessments' effectiveness. In a study conducted by Brosvic, Dihoff, Epstein, M. (2010), students' unit exam scores were influenced by the amount of time it took to receive grades on formative quizzes. The study found students' grades on exams improved when there was immediate grades and feedback given (same class period). A delay of only 24 hours proved the quizzes had no direct influence on the students' exam scores. Those students' grades were the same as the comparison group, which took the quizzes but didn't receive a grade or feedback.

Team-based learning can be an ineffective teaching method if done incorrectly. Group activities often fail to address an individual's efforts, achievements, and abilities (O'Connor, 2010). In a study conducted by Slavin (1983), the author set up a research project to determine why some collaborative efforts fail to achieve the desired outcome while others are successful. In several middle school grades (two seventh grades classes of 267, one 7-8 class of 424, one 6-8 class of 230) and one elementary grade (4th grade class of 424), students worked in small teams to learn academic content over a period of two weeks. The students were given rewards for achievement, some of which were based on individual efforts and grades, while others were based on the group's success. The author concluded that providing group rewards based on each member's individual learning and achievement showed improved learning and better test scores. Group rewards must be combined with individual accountability for collaborative learning to be effective, as the individuals with weak understanding of the material tend to be passive and those individuals with greater comprehension complete all of the group work (Slavin,

1983). Individual accountability, combined with an incentive for the advanced students to teach their peers, is necessary for team-based learning to be effective (Slavin, 1983).

“The equitable implementation of cooperative learning in classrooms depends not just on what teachers do; students’ learning depends on how they interact with one another” (Esmonde, 2007. p. 248). The issues of classroom equity in team-based learning is complex and should always be analyzed and evaluated based on the students’ gains in comprehension. In the study conducted by Esmonde (2007), team-based quizzes were given with each student earning two grades. There was a grade given to all students based on the accurateness of their work, and a second grade based on each student’s participation. A detailed rubric was used for the participation grade, which included the following: the number of students who worked on the quiz, whether they asked/explained questions, and how much of their thinking was explained. Following Slavin’s (1983) suggestion of including the essential factors of reward and accountability, a reward was given (quiz grade) and there was individual accountability (effort grade based on rubric).

Esmonde (2007) followed a group of students through one academic year. All students took a group quiz in the week leading up to a summative exam. Students with high aptitudes tended to dominate the group quiz and not take the time to explain the concepts to their peers. Teams composed of students with similar aptitudes tended to collaborate and share answers, although they frequently got stuck and had to ask the teacher for assistance. The strengths of team-based quizzes (in terms of collaboration) were student perseverance, increased discourse, and a higher level of engagement. The weaknesses were found to be students focusing on the correct answer and not the

strategy; there were also findings of low-level students being silenced and not included in the team-based quizzes (Esmonde, 2007).

Students need to be better prepared for the challenges that will be encountered when they enter the workforce. Collaboration is an essential 21st century skill that gives students the opportunity to defend their ideas, learn from their peers, and work toward a common goal. The teacher's role in facilitating a lesson and unit with team-based learning is critical in the effectiveness and outcome. Students need to be trained on how to teach one another and this needs to be transparent and assessed if it's to gain traction. Individual students, as well as the group as a whole, need to be held accountable. Without accountability, students who know the material will take over the group and complete the work with little exchange of ideas or teaching of concepts. Students must prepare outside of class by completing their individual assignments and groups must follow a rubric to ensure equal collaboration for team-based learning to work well.

METHODOLOGY

This classroom research study focused on the role team-based learning plays in student achievement. The sum of the students' efforts when placed in a collaborative group allowed for each member to make better gains in his comprehension of the concepts as well as scores on exams. Teams provided a support network needed to do well on homework, classwork, and assessments. The goal of this study was to determine whether team-based learning improved students' comprehension and achievement in the science classroom. This study was reviewed by Montana State University's Institutional Review Board to ensure that student privacy was maintained; the IRB is included in Appendix A.

The students in this study were international and domestic 8th grade boys. They attended a junior boarding school and went to class Monday through Saturday, with evening study halls proctored by their teachers. The majority of the students are from affluent homes and had an above average commitment to their studies. The treatment group and comparison group are both 8th grade boys in mixed ability classes. Cardigan Mountain School is an independent school and has a minimum requirement for admissions. Students below grade level, or needing specialized education, are not admitted, as we don't have the resources to serve that population. The students in my class brought a rich diversity of culture, native languages, and previous educational experiences. In one section of Physical Science, I had students from China, Russia, Japan, Mexico, South Korea, and the United States. Approximately 30% of the students took English Second Language (ESL) class in lieu of a World Language. Many of the international students attended "cram schools" prior to attending CMS. The emphasis of these schools is on preparing for a high-stake test, which determines a student's future. Students are discouraged from asking questions in class; lessons are teacher-focused with lecture being the primary methodology. The students in my class have quickly adapted to a student-centered and inquiry-based classroom. However, formative, low-stake quizzes still cause tremendous anxiety, as they're often associated with the high-stakes tests at home.

A class of 8th grade physical science students (comparison group) went through the three-week unit as per normal routine. These students had the same experience as the treatment group, however, they did not participate team-based learning. All of the lessons, labs, homework assignments, and assessments were the same. A different

section of the 8th grade physical science class was the treatment group. That class was broken up into small teams, each comprising three students. The purpose of the team was to provide the first level of guidance and support. Students were coached to ask their teammates for help before reaching out to the teacher.

Randomized groups were assigned on the first day of the classroom research project. Guidelines for group work were given to the students. These included: assistance on nightly homework assignments, collaborative labs, in-class note taking, self-graded participation, and group quizzes.

The students in this research project were all enrolled at a boarding school. They attended evening study hall at the same time and, with a teacher's permission, they are permitted to work together on homework. Homework done in groups was strictly limited to checking answers and giving instruction; the sharing of answers, unless used to guide instruction, was prohibited. The students' scores on biweekly quizzes, as taken by the individual student, were used to determine whether the students were following the guidelines. Students with correct answers on the homework, but with poor marks on the quizzes, were flagged as not benefitting from the group homework policy.

There were two labs completed during research project. These labs were completed in the assigned groups. The collected data was shared as a group. The reflection questions were discussed as a group; however, each student must have had his own written response. The students filled out a participation rubric upon the completion of the lab. While the individual assessed his own participation, each member of the group signed off on his score. The teacher acted as the mediator during those times of disagreement.

There were several days of teacher-focused lectures. This explanation phase required students to take notes. Groups were given time at the end of the lecture to compare notes, address muddiest points, and predict test/quiz questions. The predicted questions were answered within the group as a method to prepare for upcoming quizzes and the summative exam.

Biweekly quizzes were given to the students. These were completed on Google Forms, which were graded and returned immediately upon the class's completion. Students took the quizzes on Tuesdays and Saturdays (CMS has Saturday classes; students don't have science on Fridays). These short quizzes were taken individually and then as a team, taking no more than 15 minutes to complete both. The student's individual quiz score was averaged with the team quiz score. The quizzes were low-stake and weighed the same as a homework assignment. This was intentional, as to reduce anxiety (normalize experience), however, the grade acted as an incentive to do well.

The research cited in the conceptual framework stated the importance of student accountability (O'Connor, 2010 & Slavin, 1983). It was imperative for the individual and the group to feel some sense of urgency if team-based learning was to be effective. As an incentive for the individual, students were only able to take the group quiz if they complete the previous days' homework assignments. The group accountability was in the form of a self-assessment at the end of the quiz. The group ranked each individual based on his effort and collaboration leading up to the quiz.

Simple Machines were the focus of the unit. Students investigated, manipulated, and learned about levers, pulleys, and incline plans. The extension activity was a Rube

Goldberg challenge. The objectives, assignments, and sequence are summarized in Figure

1.

Objectives:

1. *Define machine*
2. *Identify simple machines*
3. *Explain the meaning of input and output*
4. *Define mechanical advantage in terms of input and output forces*
5. *Classify levers as first, second, or third*
6. *Evaluate the mechanical advantage of different simple machines*



Key: IC = in class; HW = homework; D = due; O = objective covered

Tuesday, January 3rd

D: Nothing **IC:** Pretest & Simple Machines Introduction " **O:** 1-6

HW: Screencast- "Introduction to Simple Machines

Wednesday, January 4th

D: Notes from video **IC:** Lab 7A & 7B **O:** 2-5

HW: Read pages 206-208; complete Section 9.1 Review question 1-6; Watch "Six Rube Goldberg Machines"

Thursday, January 5th

D: Read pages 206-208; complete Section 9.1 Review questions 1-6 **IC:** Finish Lab 7A & 7B **O:** 3-6

HW: Complete Lab 7A & 7B; Read pages 211-215; complete Section 9.2 Review questions 1-11

Saturday, January 7th

D: Lab 7A & 7B; Section 9.2 Review questions 1-11 **IC:** Quiz (Individual/Group) & Plicker Contest **O:** 1-6 **HW:** Watch screencast- "Simple Machines- Mechanical Advantage"

Monday, January 9th

D: Notes from video **IC:** Practice problems- Mechanical Advantage worksheet **O:** 1-5

HW: Worksheet "Mechanical Advantage of Simple Machines" (due on Wednesday)

Tuesday, January 10th

D: None **IC:** Quiz (Individual/Group) & Lab 7C **O:** 4&6

HW: Worksheet "Mechanical Advantage of Simple Machines"

Wednesday, January 11th

D: Worksheet "Mechanical Advantage of Simple Machines" **IC:** Lab 7C **O:** 4&6

HW: Find a Rube Goldberg Machine online (video). Send your teacher an email with a link to the video and a 3-5 sentence description of the simple machines used, number of steps, and the task accomplished (what happened at the end).

Thursday, January 12th

D: Find and write about a Rube Goldberg Machine online (video). **IC:** Tournament Day **O:** 1-5

HW: Chapter 9 Assessment, all problems on pages 222-225

Saturday, January 14th

D: Nothing (homework due on Monday) **IC:** Quiz (Individual/Group) & Misconception Probe **O:** 1-5

HW: Misconception Probe Reflection

Tuesday, January 17th

D: Misconception Probe Reflection **IC:** Quiz (Individual/Group) & Conceptual Change **O:** 1-5

HW: Study for Exam

Wednesday, January 18th

D: Nothing **IC:** Rube Goldberg Machines **O:** 1-5 **HW:** Study for Exam

Thursday, January 19th

D: Nothing **IC:** Exam **HW:** None

Figure 1. Objectives, assignments, sequence.

Inquiry data was used to assess the students' feelings and opinions on the action research intervention. Semi-structured student interviews were conducted face-to-face with six students. Individual students were picked through a stratified random sampling. There were three strata, or groups, based on the first trimester's achievement grade: group one, A (90%) or higher; group two, C (74%) through B+ (89%); group three, lower than 74%. This allowed for input from students with various levels of success in science class. Interview questions are located in Appendix B.

Table 1

Data Triangulation Matrix

Research Questions	Data Source		
1. Does team-based learning improve students' comprehension?	Quiz & Test Grades	Observational Records	Pre & Post Test
2. Will students teach and learn from their peers in a team-based classroom?	Quiz & Test Grades	Observational Records	Student Surveys
3. Is student engagement improved with use of team-based learning?	Student Surveys	Observational Records	Semi-Structured

			Student Interviews
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Student-generated artifacts were used. Bi-weekly teacher-generated quizzes were administered, as well as a unit exam. Students also completed a pre and post self-assessment.

Observational records were used during the students' group and individual quizzes, as well as during collaborative labs. The records started as data including time, task, and student behavior. The observation focused on student engagement, student achievement, and collaboration. The students' interactions with each other provided valuable information on the effectiveness of the classroom research project. The observation records were used to write a detailed narrative.

DATA AND ANALYSIS

Students in the treatment group were given opportunities to improve their understanding of science through collaboration on labs, assessments, homework, and daily activities. Team-based learning, with students learning in set groups for an entire unit, was studied to determine its affect on comprehension, engagement, and peer-to-peer interaction in the science classroom. The three research questions, as well as the data sources, are listed in Table 1.

Impact of Team-Based Learning on Student Comprehension

The first research question looked at whether team-based learning improved student comprehension in science. The results for this question are inconclusive.

Although the pre- and post-test scores did not show an improvement when compared to

the comparison groups, biweekly quiz scores showed a significant improvement over the comparison group.

The pre-test and post-test data indicates team-based learning had a slight negative impact on the students' comprehension. Students in the treatment and comparison groups took a pre-test at the start of the unit. Both groups of students struggled with the assessment, with mean scores of 32 % (treatment) and 49% (comparison) and a standard deviation of 17 and 10, respectively. The students' post-test scores improved greatly in both classes. The treatment group scored a mean of 82% (SD = 12) and the comparison group's mean was 92% (SD = 7). The treatment group's learning gain scores demonstrated an average gain of 50 percentage points out of a potential 68 percentage points; this resulted in a gain of 73% of the total possible percentage points. The comparison group's learning gain scores showed an average gain of 43 percentage points out of a potential 51 percentage points; this resulted in a gain of 84% of the total possible percentage points. These scores indicate the team-based learning may not have been as effective as the traditional model of teaching and learning. The pre- and post-test scores are summarized in Table 2.

Table 2
Pre- and Post-Test Summary

Pre-Test	Period	Average	Median	Max	Min	Range	Standard Deviation	Learning Gain
n=15	Treatment	32	33	57	7	50	17	n/a
n=15	Comparison	49	49	73	40	33	10	n/a
Post-Test	Period	Average	Median	Max	Min	Range	Standard Deviation	Learning Gain
n=15	Treatment	82	85	95	45	17	12	0.74
n=15	Comparison	92	93	100	78	222	7	0.84

In contrast to the pre and post-test data, the students' quiz scores indicates that the team-based approach had a positive impact on the students' comprehension. The treatment group's average quiz score for term going into this unit was a 79%. The students' average quiz score improved to a 95% (six quizzes given during the classroom research project). This created a learning gain for the treatment group of 90%. The comparison group's average quiz score for the term was a 91%, which improved to a 94% during the action research project. This resulted in a learning gain of 33%. The tremendous gains made by the treatment group demonstrated the effectiveness of team-based learning on student comprehension.

Impact of Team-Based Learning has on Teaching and Learning

The second research question asked: will students teach and learn from their peers in a team-based classroom? Student surveys, observations, and group quizzes showed that students engaged in peer learning as a result of a team-based classroom.

Student surveys (see Appendix C) show that team-based learning had a positive impact on student-to-student discourse, teaching, and learning. Figure 2 shows that 93.8% of the students "strongly agreed" or "agreed" with the statement, "I frequently helped the students on my team with their classwork." Equally important, the same percent of students responded to the statement, "Students on my team helped me when I needed it." Figure 3 shows the entire treatment group either agreed or strongly agreed that it was easier to learn the material while working in a group. Students worked together on teams to take biweekly quizzes. These collaborative efforts resulted in almost 90% of the students agreeing or strongly agreeing that the group quiz was helpful, as

shown in Figure 4. Figure 5 showed that the treatment group noted that the student-to-student teaching and learning was more effective than working independently.

**I frequently helped the students on my team with their classwork.
Students on my team helped me when I needed it. $N=15$**

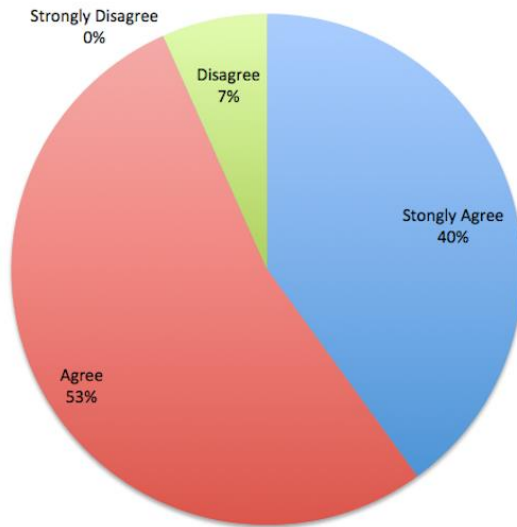


Figure 2. Student survey, ($N=15$).

**I frequently helped the students on my team with their classwork.
Students on my team helped me when I needed it. $N=15$**

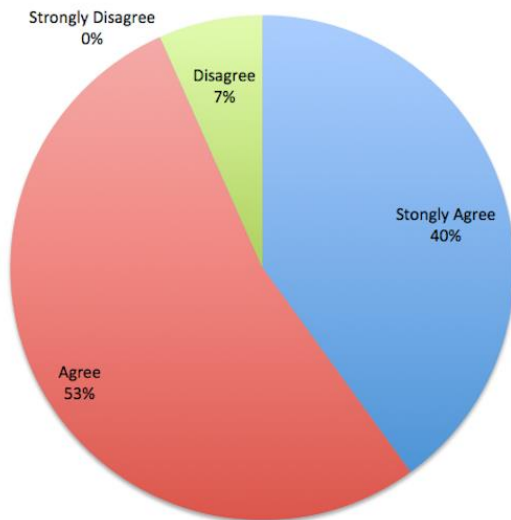


Figure 3. Student survey, (N=15).

I frequently helped the students on my team with their classwork.
Students on my team helped me when I needed it. N=15

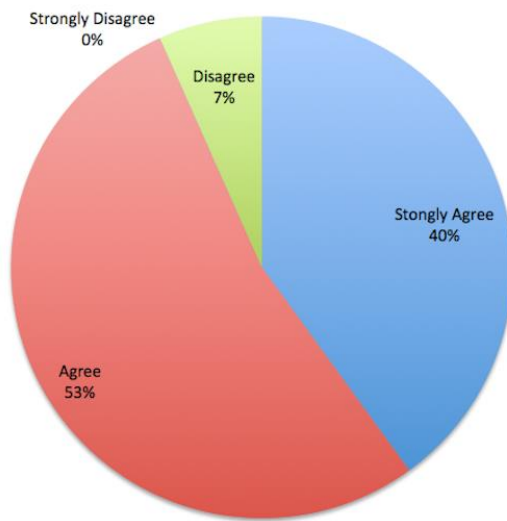


Figure 4. Student survey, (N=15).

I could have learned more if I was working by myself. N=15

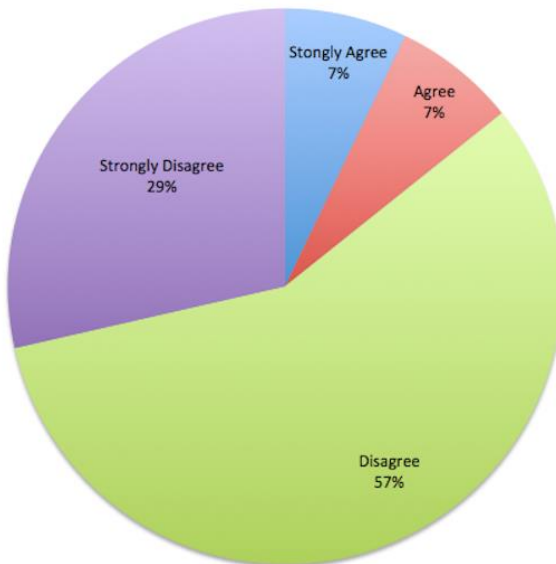


Figure 5. Student survey, (N=15).

Student-to-student discourse and “making thinking visible” are critical in the science classroom. The treatment group’s discussion was rich, focused, and deliberate. The students were observed reviewing the homework problems with intense concentration, and showing their work through written and oral explanations. The allotted time to review assignments and prepare for the biweekly quiz was considered extremely valuable to the students. “I was always trying to learn as much as I could from my friends before a quiz. I knew we only had a little bit of time, so my team always jumped right in and used every available second.” There was almost a frantic pace of support, teaching, and learning within the groups. The observations did show the opening days were not as productive. The teacher selected the groups resulted in awkward stage of students getting to know one another. It was also observed that students took several class periods for the students to acclimate to the new format, expectations, and routines of team-based learning.

Observational records show improved student achievement through team-based learning. The treatment group was given ten minutes at the start of class for each team to review the previous night’s homework, address concerns, and create/solve sample quiz questions. The students demonstrated intense focus in those opening minutes of class; they reported a sense of urgency in preparing for the quiz, checking their peers’ homework for accuracy, and generating and solving practice problems. Students were observed helping, and being helped, on their homework and practice problems. Many of the student-generated questions were similar to those on the graded quizzes. The teams

showed pride when the members of the group earned a high mark, and there was tremendous excitement when a quiz question was the same as the team-generated question. Observational records showed students on-task and assisting their peers, and there were no records of poor student behavior.

Providing time for the students to think critically about their work, collaborate with their peers, and ask clarifying questions likely contributed to the improvement in grades and comprehension. The comparison group was observed turning in their nightly assignments without reflection, even though they were given an opportunity to ask clarifying questions and check-in with their peers. These students didn't show the same commitment, investment, and care for their peers' success. These observations illustrate the importance of individual and group accountability in the team-based learning model.

Impact of Team-Based Learning has on Student Engagement

The third research question looked at the effect team-based learning had on student engagement in science class. There is strong evidence to show the collaborative nature of the treatment class improved student engagement in science.

When surveyed, 15 out of 15 students in the treatment group either agreed or strongly agreed that team-based learning was enjoyable and made learning fun. 14 out of 15 of the students wanted to apply team-based learning to future units. Student interviews showed a strong desire to continue to work in teams. "I really liked having a team to work with through the entire unit. In the past we worked in groups, but it was different with the team. We were together the whole time, and we helped each other with homework, labs, and quizzes. It was also a lot of fun. And I hope we get to do this again." The students' commitment to their teams was far greater than previous group projects.

Students demonstrated a greater commitment and engagement with their homework assignments. The homework completion rate prior to the classroom research project was at 90% and 95% for the treatment and comparison groups, respectively. These numbers increased to 100% homework completion for the treatment group, while the comparison group dropped slightly to 93%. Students in the treatment group reported the importance of completing the homework, as without perfect homework completion, they weren't able to take the group quiz. "The group quiz really helped me. The other students explained how to get the answer, and once in a while I was able to help them, too. I needed to get my homework done, otherwise it wouldn't have done as well on the quizzes and test." Students recognized that they had to be prepared for class if they were to help their group; this incentive kept the students' engagement in their studies of science extremely high.

INTERPRETATION AND CONCLUSION

The results from the team-based teaching and learning didn't have a definitive conclusion on its impact on student comprehension. Test scores from the comparison group showed greater improvement than that of the treatment group. Both groups' overall grades improved; however, the treatment group's total possible gain was 14% lower than the comparison group. Studies have shown that the collaboration should have had a greater influence on the students' test marks. "Both theoretical and empirical literature supports the power of giving explanations compared to other kinds of participation such as giving answers. Researchers theorize that giving explanations to others promotes learning by encouraging the explainer to reorganize and clarify material, to recognize misconceptions, to fill in gaps in her own understanding, to internalize and acquire new

strategies and knowledge, and to develop new perspectives and understanding” (Webb, N., Franke, M., Ing, M., Chan, A., De, T., Freund, D., Battey, D. (2008). p. 361). In contrast to the exam grades, the treatment group’s biweekly quiz scores showed greater improvement. The team-based approach provided a daily opportunity for students to discuss, defend, and explain the nightly homework assignments prior to the low-stake assessment. This gave the treatment group a learning gain of 90% while the comparison group’s learning gain was limited to 33%. The findings on improved quiz grades are supported by Brown and McDaniel (2014) who found incorporating frequent, low-stake quizzes improves student retention by making them active and critical learners.

Team-based learning had a positive impact on engagement in the science classroom. The students were observed being more proactive in their studies and more committed to helping their colleagues. The students’ feedback was overwhelming positive. They found the long-term relationships with their peers were more meaningful than working independently or with a group for a short-term project. There was a sense of pride in doing well, both as an individual and as a team. 94% of the students agreed or strongly agreed that they gave help to their peers and received help. The observations showed that help was sincere, and there was an urgency to give help on the team quizzes and labs. It was found that collaborating and benefiting from diversity rather than promoting homogeneity produced greater results for the students in the classroom (Azzam, 2009).

Individual accountability is paramount for team-based learning to be successful. The poor-performing students have a tendency to allow the higher-achieving students do the work if permitted (O’Connor 2010). The students who struggle with the concepts

become passive unless there is an incentive for the individual to participate in the team-based model. The homework completion acted as one form of student accountability. Students found value in taking the quizzes as a group after completing it independently (see Figure 3); this was not an option unless the individual completed the previous nights' homework assignments. The homework completion rate was 100% for the treatment group, which showed the importance the students placed on working as a team during class.

VALUE

Team-based learning is spreading roots and evolving in my classroom. Due to the students' overwhelming support of this model of teaching and learning, it's being used for next year's three major PBL units. The students will be assigned a team at the start of the year and will work with those peers through each term's project. The classroom action research project showed there is importance in using the team to help support engagement and learning, and providing the same team for all three projects will allow for greater continuity, familiarity, and enhanced collaboration. There is a risk the team will become stale or have bad chemistry, but the benefit of a long-term relationship should outweigh these concerns.

The observations made during team-based learning showed students highly active in peer-to-peer teaching and learning. This was most evident in the window of time prior to a biweekly quiz. There was less than ten minutes for the students to review the previous night's homework, ask questions, and discuss possible quiz questions. Moving forward, I will allot additional time for this rich collaboration. I believe giving ten to fifteen minutes will allow greater discourse and enhanced student comprehension.

The use of data in reflecting on my teaching practice has been transformational. Allowing the data to tell a story provided a more objective lens to evaluate and reflect on teaching and learning. It helped remove the emotion assessing the effectiveness of the classroom intervention. The inclusion of data acted as a catalyst for inviting more of my colleagues into my classroom. The data proved to be the focal point for my professional learning community; they asked and answered questions, provided support and guidance, and took my best practices to try in their own classroom.

The use of data will spread throughout my school's PLC. Next year, I've been tasked with supporting teams of teachers as they design a classroom action project. They'll use a similar, albeit truncated, process that I went through. The research and conceptual framework will be partially done through a series of mini workshops by a professor at a nearby university. The teams will conduct their intervention and then report back their findings to the faculty, which will hopefully lead to improved teaching and learning.

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APPENDICES

APPENDIX A
INSTITUTIONAL REVIEW BOARD



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Joseph Doherty and Eric Brunsell
FROM: Mark Quinn *Mark Quinn*
DATE: December 1, 2016
SUBJECT: "The Effects of Team-Based Learning on Student Achievement in Science" [JD120116-EX]

The above research, described in your submission of December 1, 2016, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☒ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- ☐ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B
SEMI-STRUCTURED STUDENT INTERVIEWS

1. After participating on your science team, do you feel you understood the material better, worse, or the same as before you worked on a team? Why?
2. If you had the choice of working on a team for your other classes, would you do it? Why or why not?
3. How often did the students on your team help you with classwork, homework, and group quizzes?
4. How much fun did you have while working on your team? Did you enjoy it more than the “normal” class?
5. What could I do to improve team-based learning in science class?
6. Do you think we should continue team-based learning in science class? Why or why not?
7. Is there anything else you’d like to tell me?

APPENDIX C
STUDENT SURVEY

(Circle either Strong Agree, Agree, Undecided, Disagree, or Strongly Disagree)

1. It was easier to learn the material in science class when working with a group.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

2. The grade I got on the unit test was higher than the grades on previous tests.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

3. I frequently helped the students on my team with their classwork.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

4. Students on my team helped me when I needed it.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

5. I enjoyed working with the students on my team.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

6. I hope we will get a chance to work on teams again in science class.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

7. Taking the quiz as a group helped me learn the material better.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

8. Most students took the group learning seriously by teaching and learning from each other.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

9. It was boring working on a team.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree

10. I could have learned more if I was working by myself.
Strongly Agree-----Agree-----Undecided-----Disagree-----Strongly Disagree