

THE EFFECTS OF GOAL SETTING AND REFLECTION ON MOTIVATION AND
ACADEMIC GROWTH IN A HIGH SCHOOL SCIENCE CLASSROOM

by

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ABSTRACT

An educator's role is to help their students to develop into well rounded humans. Teaching skills that will be valuable for everyone no matter what career they may proceed is essential for all teachers. Goal setting is an extremely beneficial strategy to reduce stress and help people be successful in all realms of life, not just school. The purpose of this study was to look at how goal setting and reflection would affect students' motivation and self-efficacy as well as help them be more academically successful. The study had students set academic and personal goals, using the S.M.A.R.T. goal setting methods. Students regularly reflected on their goals and edited them based on changes, both successes and failures. During both the non-treatment and the treatment unit, varied quantitative and qualitative data was collected and interpreted to compare changes in motivation and academic growth between units. There was a significant increase in test scores during the treatment unit as well as a notable increase in motivation and students' attitudes in class. Students learned a skill that showed them academic success allowing them to become more confident in class and also potentially out of class.

INTRODUCTION AND BACKGROUND

Project Background

When attempting to brainstorm ideas for a research project I was trying to think of a project that would affect all of my students. I teach three inclusive co-taught biology classes and two honors biology classes at Naperville Central High School in Naperville, Illinois. These classes expose me to the whole gamut of students at my school. I have a large number of students with accommodations in the form of 504 plans and Individualized Education Plans (IEPs). Coming up with a strategy that would work well to increase academic success for all of these students was unlikely. Instead of focusing on academic strategies that may increase performance and self-efficacy in my class for some of my students, I began to brainstorm skills that could potentially benefit my students in more than just my classroom.

Part of my high school's mission statement was just amended to include the focus on social and emotional learning. This change was based on the advent of Illinois States Social Emotional Learning (SEL) Standards. Many states are writing standards that focus on students' comfort and social/emotional well-being. All of these standards aim to build a positive self-efficacy and self-confidence so students can learn better and be better people. My research will directly relate to these SEL standards.

I am hoping to positively affect my students, so they can be successful in all realms of their life. By compiling research on positively affecting intrinsic motivation and confidence, I am hoping to create an even more positive environment within my class and in our school. The techniques that I am going to employ will be beneficial in all

classes at my school and others. I hope that I can build on the research of others with data collected within the classroom.

Through research and reflection, I saw that reflection and goal setting are very beneficial skills for students to learn. If done well, students will become more intrinsically motivated in class and build confidence. I want to teach my students a skill that will be beneficial in all aspects of their life. An increase in confidence will affect all aspects of a student's academic and social life.

Research Questions

While reflecting on my student's needs, I formulated the following action research question: "What impact does regular goal setting and self-reflection have on student self-efficacy and academic success?" While pursuing my main research I will also be focusing on the following related questions:

1. How do goal-setting strategies affect my students' opinions of biology and science classes?
2. How does a student's belief in how they learn (growth vs. fixed mindset) relate to their self-efficacy?
3. How does self-efficacy of my students relate to their academic success?

CONCEPTUAL FRAMEWORK

Introduction

Self-motivational beliefs held by students are one of the most important factors in a student's academic success, if not the most important (Kharazzi & Kareshki, 2010). Motivation has a major influence on a student's ability to succeed to their potential.

There are many factors that can affect student motivation such as self-reflection and goal setting. Investigating different teaching philosophies and research regarding motivation was the logical step toward understanding what may help students have better self-efficacy and hopefully increase their academic success.

Direction for Investigation

A greater understanding of the philosophy behind student learning is necessary to teach purposefully. Schmidt, Shumow, & Kackar-Cam (2017) looked at the idea of fixed mindset versus growth mindset. In the article, the authors suggest that students that have a growth mindset are much more likely to “relate successes and failures to controllable causes” (Schmidt et al., 2017, p. 583). Students’ perception of their ability to learn relates to how they learn. This will greatly influence their self-efficacy and motivation. A students’ academic success may have a direct correlation between success in goals and academic success. Seeing that failure is connected to something changeable and not due to a lack of ability can greatly impact a student’s ability to persevere.

Margolis & McCabe’s work (2006) explained self-efficacy issues in students as well as outlined solutions and strategies to help them. Margolis & McCabe start off the article by stating that, “many students believe they cannot succeed in school” (2006, p. 219). This statement is extremely important. The success they are referring to is in everything they do not just in science class. Confidence is directly tied to a person’s ability to perform at or near their potential. The authors go on to explain that students that do not believe in themselves tend to struggle and continually do poorly. They will then

think they are failures and lose even more self-esteem and therefore fall in to a self-fulfilling prophecy of failure (Margolis & McCabe, 2006).

In order to break this very negative positive feedback loop, a teacher needs to step in and create an environment that is able to build positive self-efficacy. Margolis & McCabe (2006) outline a handful of very practical methods of increasing self-efficacy in students. Two methods that were really impactful are: “teach specific learning strategies” and “capitalize on student choice and interest” (Margolis & McCabe, 2006, pp. 220-221). These two strategies seemed very important in terms of creating a classroom environment that would build self-efficacy. Margolis & McCabe’s tenets apply to academic learning and growth, but can also apply to learning strategies as well.

The ideas from Margolis & McCabe regarding “specific strategies” and “student choice” and ownership apply to the idea of self-reflection and goal setting in class. Goal setting is a very personal and potentially motivating tool that can be used to help students see their strengths and weaknesses in a positive light. They can then take this information and learn from it through self-reflection. This will hopefully help them see their failures in a positive light, reducing the negative effect of failure. This personal self-reflection can also help students be encouraged by their successes and strengths.

Traverse, Morisano, & Locke (2014) shows how self-reflection and goal setting can directly affect a student’s academic success. Traverse et al., states that goal-setting theory is “among the most popular” theories in regards to increasing student motivation (2014, p. 224). Setting goals that are personal, specific, and obtainable are the three tenets that Traverse et al. urge should be incorporated into goal setting and reflection strategies

(2014). If the goals are vague and impersonal, students will not take ownership. This idea was echoed by Margolis & McCabe (2006) concerning how to best increase student self-efficacy.

One of the major findings of Traverse et al. (2015) was regarding the manner of the goals being set by each student. They stated that goals need to be specific and personal to each student. Their findings also showed that academic goals and non-academic goals are equally important and both can lead to positive results when it comes to academic success. Students having freedom in their goal setting method allows them to be reflective in a manner that is best for them. Some students may need to start with goals that relate to study skills, organization of thoughts, and other skills that are not directly content driven.

I am hoping that a lot of my students will utilize the Next Generation Science Standards Science and Engineering Practices as part of their goals. These skills are practical in all content areas and will help students to become better students in general. If they can see growth in other classes as well as mine, my strategies will be an even bigger success. If they see these successes related to their reflection, then they will hopefully become more motivated overall. This motivation that is derived from the goal setting and reflection strategies will be the driving force for academic success.

Theoretical Framework

In order to see results from the implementation of goal setting and reflection, an understanding of student motivation was necessary. Ryan, Deci, Fowler, Raymond, Seligman, Martin, & Csikszentmihalyi (2000) give a great overview of the Self-

Determination Theory (SDT) and how it relates to different forms of motivation. In the article, motivation is described, and intrinsic and extrinsic motivation are compared and contrasted. The authors include a great concept map showing the different types of motivation and what they call “regulatory processes” (Ryan, et al., 2000, p. 70).

The article breaks motivation up into six different types and focuses on the meaning of these motivations. A type of extrinsic motivation, called “identified regulation extrinsic motivation,” (Ryan, et al., 2000, p. 74) is the type of motivation that applies to my study. This type of motivation is looking at how external stimuli can affect internal personal awareness and importance. True intrinsic motivation is very difficult to measure and is difficult to link with what is done in class. Ryan and his coauthors’ interpretation of intrinsic motivation truly shows how difficult it is to observe and measure it quantitatively.

In another article, *How Self-determination Theory (SDT) Can Assist Our Understanding of the Teaching and Learning Processes in Medical Education*, the authors define SDT as “a theory of motivation and can be best described as a set of psychological mechanisms relating to the self, founded on a series of principles generally proved valid in experimental investigations” (Kusurkar, Croiset, & ten Cate, 2011, p. 962). The SDT states that student’s intrinsic motivation is directly related to creating feelings of competency and autonomy. This relates back to Margolis and McCabe (2006) when they describe self-efficacy in students. When a student receives specific regulations they will inherently be motivated. So if positive behaviors are rewarded trust can be built

and students will feel competent and autonomous. This can translate to growth in academic measures.

In Kusrkar et al., reinforcement and punishment, or fear of punishment, were linked to different levels of motivation (2011). Accepting this relationship allows student behaviors to be related to the basics of human and animal behavior. The article mentioned that punishment and fear of punishment tend to lead to low level motivation and don't really build high levels of extrinsic or intrinsic motivation. Building real confidence and high levels of ownership and autonomy in students is extremely important. Focusing on communication of goals and struggles is a great way to build confidence and comfort in students and all people.

Methodologies

Kusrkar et al., (2011) list 12 tips to increase intrinsic motivation in students. The 12 tips are meant to build autonomous learners that are confident and motivated to be successful. The article stresses that incorporating parts or multiple tips into lessons will help to increase motivation but all cannot be utilized all the time. These tips can be used in any style of class and also with any style of teaching.

The 12 tips were very helpful in structuring this studies treatment. The two tips that were utilized during the study were, "identify and nurture what students need and want" and "encourage students to accept more responsibility for their learning" (Kusrkar et al., 2011, p. 979). These two tips are extremely relevant to goal setting and reflecting. In order for students to realize the importance of the techniques, they need to see the value in the technique. The students need to be invested in and have ownership of

the practices used. In order for students to express openly and honestly, they need some autonomy and even potentially privacy in some of their reflecting and goal setting.

Classroom Goal Structure, Student Motivation, and Academic Achievement by Meece, Anderman, & Anderman (2006) go into great details about specific goal setting strategies and philosophies. The author relates a teacher's goals in class to what students think the class's goals are; there are very often misconceptions. Being very deliberate with communication of daily targets and what is important is extremely important for students to be successful academically in class. Students will set goals that are specific to their needs while still being reflective of the class's targets. Differentiation based on students' needs and abilities is extremely important for maximum student growth.

Bannister (2016) states that differentiation is a must for all students to be as successful as possible. Without differentiation students can even be negatively impacted. Since goals are personal this small differentiation can effect self-efficacy. Growth in self-efficacy is the job of an educator and will also prepare them for success in class and beyond.

Moeller, Aleidine, Theiler, & Wu (2002) state that building an understanding of goal-setting and its purpose is necessary to teach the students how to set affective goals. The utilization of pre and post surveys to see what students' goals are and if they feel they achieved them is necessary to see change. Data will need to be collected throughout the process to gauge students' opinions of themselves and the process of goal setting. This data will give some insight into my students' intrinsic motivation and self-efficacy. These surveys coupled with the utilization of large amounts of qualitative data through

interviews and the students' reflections, allows for the correlation of the goal setting strategies to academic success and motivation.

Taking the findings and ideas from my readings, I structured my treatment to help all of my students in some way. Building on the SDT and practices designed by prior researchers, I planned to look at the connection between self-perception and self-efficacy and academic success. Goal-setting, being a tried and true practice that has been linked to success was a logical tool to incorporate in my classes.

METHODOLOGY

Introduction

The main treatment that was employed was the incorporation of goal-setting and reflection strategies. The process of implementing goal setting strategies started by trying past goal setting strategies acquired from colleagues as well varied online resources. In order for consistency, instrument reliability, and validity and a tie to best practices Dr. Locke's Goal-setting Theory was utilized as the main strategy (Locke, Shaw, Saari & Latham, 1981).

Goal-setting theory is a theory involving setting goals in order to increase intrinsic motivation and success in accomplishing the goals themselves. Locke created five steps to good goal setting which were incorporated into three sophomore co-taught biology classes. At the beginning of the treatment unit, a brief tutorial of Locke et al., (1981) goal setting tenets were presented and modeled for the students. The students walked through the goal setting technique prior to the treatment unit.

Participants

All three classes of general education co-taught biology students were evaluated in order to effectively draw conclusions about the treatment method. A large sample of 78 students from three class periods was the main sample size. The students in these classes were a mix of students with special education accommodations and general education students without accommodations. There were 43 male students and 35 female students within these classes. According to The Illinois State Board of Education, Naperville Central High School has 13.5% of the student population receiving free and reduced lunches. This compares to the state average which is 49.5% (2018). Naperville Central is a relatively affluent community with many resources available for students that need food or help for other needs.

There were 18 students with Individualized Education Plans (IEPs) and 14 students with 504 plans. The IEPs and 504 plans differ in terms of accommodations. The majority of students with IEPs receive academic accommodations, such as extended time on test, verbal assessments, and differentiated assignments. The majority of students with IEPs have Attention Deficit Hyperactivity Disorder (ADHD) or anxiety disorders. These disabilities often hinder the student's success inside and outside of class. Being able to increase self-efficacy would greatly help this group of students. Males that receive accommodations outweighs the females by 15% as shown in Figure 1.

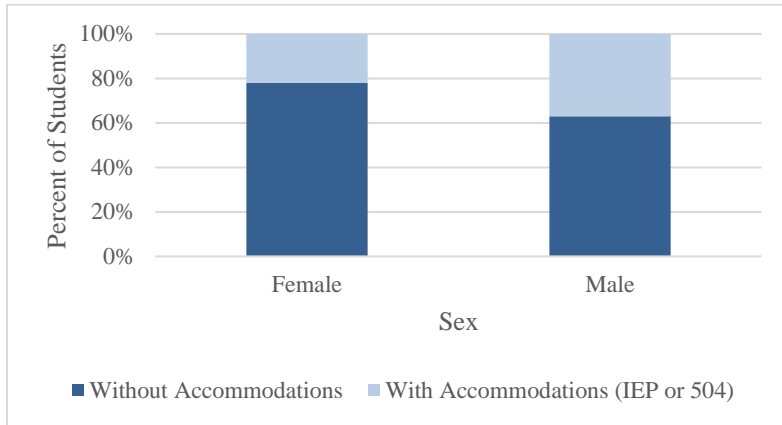


Figure 1: Percentage of students with and without accommodations by gender, (N=78).

In preparation for beginning the non-treatment unit of the action research project, overall grades of each student were collected for all three class. The distribution of grades for all of my students versus the distribution of students with accommodations, in the form of 504 plans and Individualized Education Plans (IEPs), was compared (Figure 2).

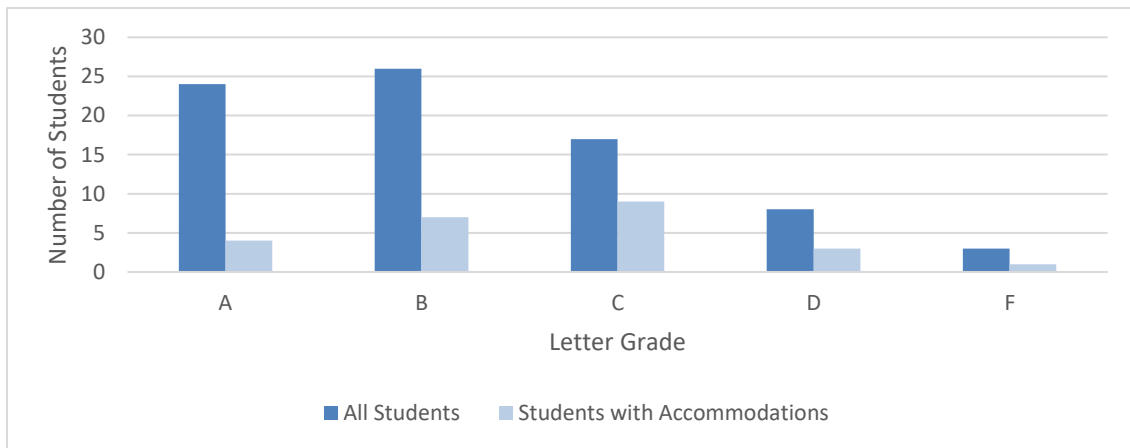


Figure 2: Distribution of grades for students in biology compared to students with accommodations, (N=78).

This graph shows a discrepancy between the students with accommodations and the students without. The average grade in class is an 87% with a standard deviation of 11% while the average grade for students with accommodations is a 78% with a standard

deviation of 11%. This inequity of academic grades is worrisome, which led to the choice to focus on a technique that could help students that need accommodations while also allowing for growth in non-accommodated students.

The administration at Naperville Central High School has exempted the research carried out in this study. The sample and instruments have been approved by the MSU International Review Board. All participation was optional and did not impact the student's grades at all. Students and administration were extremely cooperative with all aspects of the research (Appendix A).

Treatment

The five tenets of Dr. Locke's Goal-setting Theory (Locke, et al., 1981) are Clarity, Challenge, Commitment, Feedback, and Task Complexity. Students created short-term goals for parts of the unit and medium term goals for the whole unit itself. The first tenet Locke outlines is clarity. In order for the students to create goals that were clear they used the SMART method for goal setting. SMART stands for Specific, Measurable, Attainable, Realistic, and Timely. During the treatment the students wrote goals that were specific, measurable, attainable, realistic, and timely. Along with a strong clear goal, students created goals that were Challenging. Students were pushed to grow in all areas of their lives not just academically. Goals were created and evaluated in class and monitored throughout the process.

Students created multiple goals; at least one academic, one school task/ behavioral goal, and one short term life goal. Allowing students freedom in their goal setting allowed them to be more Committed to the outcomes of the goal setting and reflection. If

it is important to them, then they are more likely to stay motivated and see value in the exercises. Since accountability is extremely important to increasing buy-in and success, students were encouraged to help each other be more successful in their goals, especially if they shared similar goals.

The next tenet of Locke's is Feedback. Students received feedback initially when they were creating their goals as well as throughout the process. They had check-ins during the unit and students reflected on what they had done to move toward success or toward failure. Students worked with accountability groups during the unit to check-in as well.

Students recorded their goals and started their reflections on a SMART Goal Worksheet, either digitally or on paper (Appendix B). Students had the option of how they wanted to reflect. Goals and reflections were always collected or directly with their instructor via Google applications.

The last tenet of Task Complexity goes directly with SMART's A, R, and T Accountability, Realistic, and Timely was discussed when they created their goals. Students had to create goals that could be reached in the timeframe of the unit. They also set goals that would last longer, but their academic goal had to be finished prior to the unit assessment of the treatment unit. These goal setting techniques are the foundation of the treatment unit.

Non-treatment and treatment data was collected during the first semester of the school year. The first unit of the year was general biology concepts and science practices. The study began during second quarter. Second quarter mainly consists of two units that

are approximately four weeks each. These two units are nearly identical in terms of length, amount of assessments, labs, and classwork.

A non-treatment unit was administered first followed by the treatment unit. The treatment unit contained an introduction to the idea of SMART goals. After learning about SMART goals students completed goals using the SMART goal worksheet and reflections on a bi-weekly basis (Appendix B). These goals and journals were evaluated after each class session. This allowed students to reflect in their journals and keep an open dialogue with themselves and their instructor. The introduction of SMART goals, setting goals, and reflecting on their goals, was my treatment and the only major change in teaching style between non-treatment and treatment units

Data Collection

During the first quarter informal information about students was collected and classroom procedures and academic expectations were set. A baseline for academic achievement in class was also observed. Students took a general information survey, via Google forms, over the first few days of class to show their initial thoughts about learning philosophy, their comfort and confidence in science and school, and their understanding and experience with goal setting and reflection techniques. Some general, get to know you questions regarding their needs and interests were also added to help create good student-teacher rapport (Appendix C).

During first quarter a baseline of information including academic achievement in class based on general summative assessment information was collected. This data was not easily comparable to the non-treatment and treatment data. Since the treatment, the

introduction of the SMART goals system and reflection, was not directly academic, the previous academic data was used minimally. The main academic comparison observed was that of the treatment and non-treatment unit assessments. The units at the beginning of the year were far less controlled in terms of testing and presentation styles, so any comparisons would be purely subjective and for general evaluation of the students.

The first instrument that was used to collect data related to students' self-efficacy, motivation, and opinions of school. A Likert style pre-treatment survey (Appendix D) was administered. This survey was quantifiable and thus could be analyzed statistically, looking at percentages. Likert scales could also be used to gain a better big picture understanding of what the students were thinking. These quick surveys took very little class time but provided very valuable information. The Likert survey was designed in conjunction with multiple high school teachers as well as a learning behavior specialist. The Likert surveys were based on the Barros, Marcelo, Laburu, and Silva (2010) tool, as well as prescreened questions that were used and edited through two other classes of students. Using this published, vetted instrument helped with the validity of the instrument used in class.

For the treatment unit data was collected in various ways. Each unit began with a survey (Appendix D) and an academic pre-test (Appendices E & F). All data was collected via Google forms. This allowed it to be collected and analyzed very quickly and easily. This also allowed students to track their information very easily without worrying about losing worksheets. Comments were given directly on students' work through Google classroom and students were able to comment back if they wanted to. This open

dialogue allowed for feedback between the instructor and the students, as well as allowing for collaboration with each other.

Both units started with a pre-test that covered the main concepts of the unit. The units then ended with the unit assessment that was identical to the pre-test. The non-treatment unit tests covered photosynthesis topics (Appendix E). The treatment unit tests covered cellular respiration topics (Appendix F). This allowed academic growth to be easily seen within the units and between the two units. The Pre/Post tests were academic assessments to mainly gain insight into academic growth through the units. These tests allowed for interpretation of growth in an individual student and also the comparison of classes to each other. These tests were created, administered, and edited by all general level biology teachers in Naperville Unit School District 203 for the past three years. This allowed for some validity and reliability in the academic instruments.

The third instrument that was utilized was even more qualitative than the open-ended questions from the survey. Short, one-on-one interviews with random students with special education accommodations and the group without accommodations were administered. This allowed for information from students to be gained and students to be probed for more information and better explanations of their responses. These interviews helped fill in not completed student surveys. The student interviews were very informal and very qualitative. Students were randomly selected for individual interviews from each lab group during independent work times. This allowed for deeper questioning for a wide range of students.

Informal observational data was also collected in order to gauge student motivation and confidence in the goal setting strategy and also in their academics in general. All of these data collection methods were utilized throughout both the non-treatment and the treatment units.

Through these methods of data collection, an understanding of my student's self-efficacy, their motivation, and their perceptions of class and the methods used within class was gained. Since these factors are based on my student's opinions and perspectives, surveys are the best means of collecting data. By varying the time and style of survey/interviews, a holistic perspective of the classes and whether their opinions of themselves and class have changed because of the goal-setting methods utilized in my treatment unit could be gained.

Information was also gathered about whether or not the students took the goal setting seriously. During each reflection session students were randomly chosen for interviews about the process. Their goals were then evaluated via screening the sheets allowing outliers for the study to be identified. Student understanding of the goal setting techniques could also be evaluated during these informal conversations with the students.

Preparation

All of the questions pursued through the action research process utilized the survey that was given pre-treatment (Appendix D). The main question investigated, "What impact does regular goal setting and self-reflection have on student self-efficacy and academic success?" will gain a foundation using the data from this initial survey. All sub-questions also will get baseline data from the initial survey. Some of these questions

will get all of their data from the pre and post treatment surveys and interviews while a few of the questions need academic data in order to draw conclusions. In order for me to clearly answer any of these questions I needed my post treatment surveys to see what changes.

Triangulation Matrix

Various forms of data were collected in order to have various perspectives of the results. For the main question and all of the sub-questions, quantitative data and qualitative data were collected. Every research question had at least two pieces of data collected to answer it, as shown in Table 1. Each instrument utilized has been approved via MSU IRB exemption and Naperville Central High School administrative permission (Appendix A).

Table 1
Data Triangulation Matrix

Data Triangulation matrix Research Questions:	Data Sources				
	Student Informational Survey	Pre-test/ Post-test	Student SMART goals and reflection sheet.	Individual Student Interviews	Teacher Feedback observations
What impact does regular goal setting and self-reflection have on student self-efficacy and academic success?	B,C,D,E,F Q	A #	B #, Q	B,C,D,E,F Q	A,B,E Q
How do goal-setting strategies affect my student’s opinions of biology and science classes?	E,F #, Q			E,F Q	E,F Q
How does a student’s belief in how they learn (growth vs. fixed mindset) relate to their self-efficacy?	C,E #, Q			C, E Q	C, E Q

How does self-efficacy of my students relate to their academic success?	B,C,D Q	A #	B #, Q	B,C,D Q	A,B,E Q
How do students with IEPs and 504 plans compare to students that do not receive accommodations?	Q		Q	Q	Q

Key: Reason for using this form of data collection:

- A) Data will show student's academic growth.
- B) Data will show student's understanding of goal-setting and reflection.
- C) Data will show student's understanding learning philosophy.
- D) Data will show student's opinions.
- E) Data will show student's motivation.
- F) Data will show student's confidence.
- #) Quantitative Data directly collected.
- Q) Qualitative Data collected.

DATA AND ANALYSIS

The Likert survey was the first major data collecting instrument that was used (Appendix D). The survey was utilized as a pre-study survey and a post-study survey. The data from the survey addressed students' self-efficacy, motivation, and opinions of school. This survey contained Likert style and free response questions. Questions were broken down and grouped based on these three different categories. These Likert prompts were not part of a vetted Likert scale, but they were still evaluated as holistic groups. Some free response questions in the survey related to the choices that the students made.

The first sub-question of the research was, "how do goal-setting strategies affect my student's opinions of biology and science classes?" The Likert survey was filled with questions regarding students' opinions (Figure 3). These questions were compiled and are shown comparing the changes between the pre-study survey and the post-study survey.

Always and Usually, both positive responses, were selected the majority of the time. The data showed that 84% of the students believe they try their best. Not one student had a negative response in regards to trying their best. Students that responded positively stated that they enjoy school for three main reasons: they “see their friends”, they “want to be successful”, and they “enjoy it.” Of the students that responded negatively, 100% of them either said they have “no friends” or they “don’t like to wake up.” Since the study began after students already had a relationship with their teacher and the class the goal-setting strategy did not appear to show any significant change between the pre-study and post-study surveys (Appendix D).

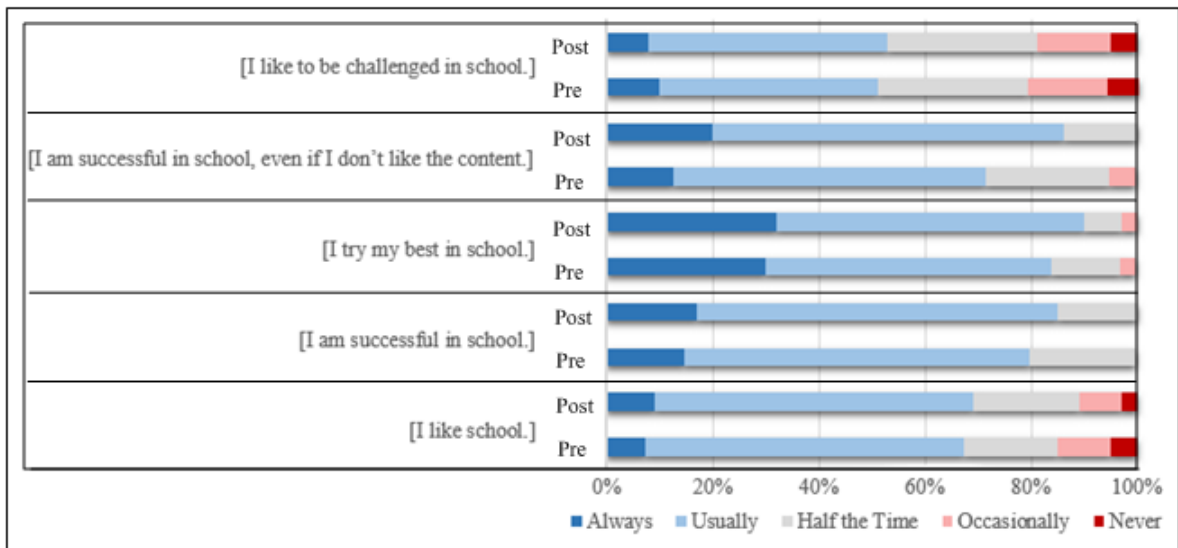


Figure 3. Students’ opinions of school, (N=78).

The next set of data shows students’ opinion of science and science education (Figure 4). Students have a lower opinion of science compared to school as a whole, 69% of students reported a positive response toward liking school while only 54% reported a positive response to liking science. When a t-test was run to compare the pre-study and post-study data for the above Likert prompts, only the prompt “I Like Science” showed

any significant statistical difference. This prompt had a p-value of 0.05548, which is just above the accepted p-value of 0.05. All of the other prompts in Figure 3 and 4 had p-values above 0.1, most had values between 0.3 and 0.5. This shows that there is no significance between the pre and post data for these responses.

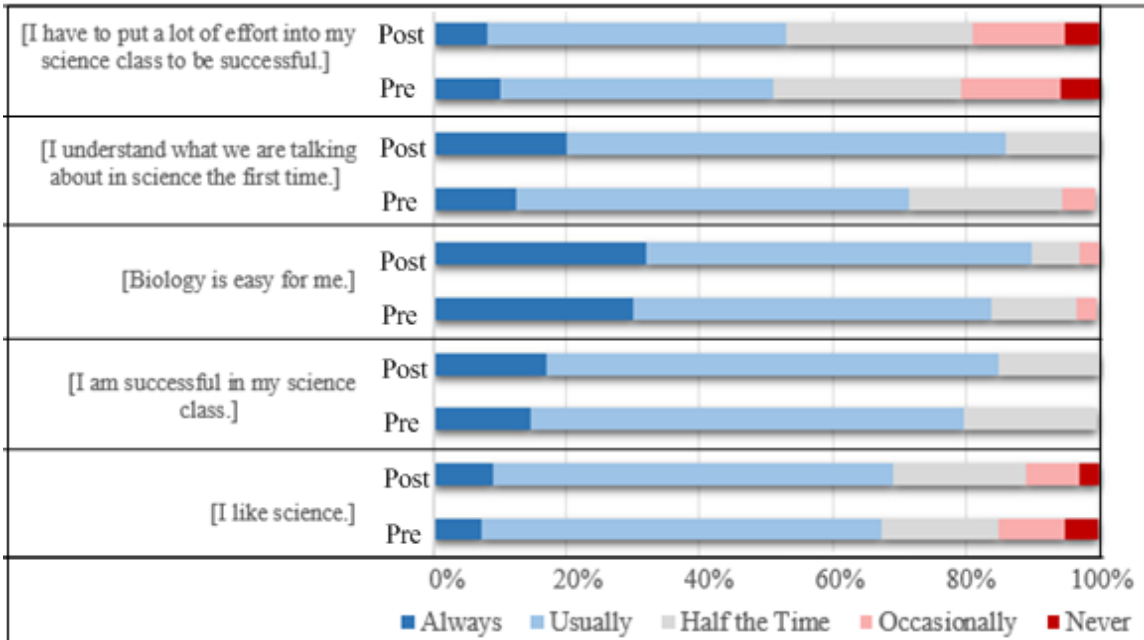


Figure 4. Students’ opinions of science, (N=78).

When interviewed about what was the reason for an increase in liking science students gave many varied responses. Most students that were interviewed shared that every school year is different and that their perception of a subject is highly dependent on the teacher and the people in the class with them. One student said, “As the year goes on I am becoming more comfortable with you (the instructor) and my classmates. I also like the units better now.” Another student said, “I like the stuff we’re doing now and I’ve warmed up to class.”

Twenty seven percent of students said that they have to try real hard in biology class. This, compared to a 54% of students enjoying science is of interest to me.

According to the written responses for this group of questions, the most common answer among all the different levels of Likert data was that students generally find science hard. This was a common response even among students that responded that they love science. Students that had negative responses either said it is difficult or that they don't enjoy it. These negative responses were generally very short and vague. Of all the students, 24% of them are interested in pursuing a science career. All of these students responded positively to all of the prompts in this section. Students' opinion of science appear to remain fairly stable when non-science practices are introduced in class. The students appear to recognize that even if the treatment causes them to be successful, the goal setting techniques were not science-related.

The next set of data shows how and if students pursue help in science, when they believe they need it. Figure 5 shows that that all three prompts showed an increase in positive responses. When a t-test was run for the three science help prompts all three showed statistical significance. The "I make lists" prompt showed the most statistical significance with a p-value of 0.001549. The other two prompts had p-values of 0.04892 for the "I seek help" prompt and a p-value of 0.04629 for the "I record homework" prompt. It is rare for a student to pursue help even when they are doing poorly. Students showed positive growth in the area of help when interviewed and using the short response from the Likert survey (Appendix D). A student shared, "I feel more comfortable seeking help as the year goes on and I become more comfortable in class." Another student said, "Since we started setting goals in class I have begun making lists on my computer." Multiple other students shared that they now find themselves making lists either in or

outside of their assignment notebook. When the students learned and saw success with the goal setting technique, they were more likely to use it in their life.

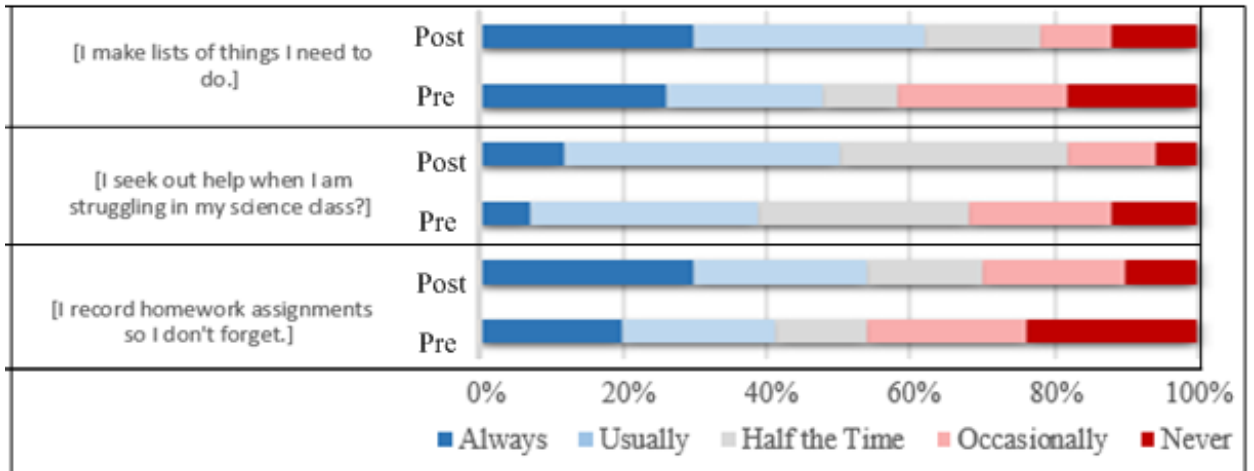


Figure 5. Students that pursue help for science class, ($N=78$).

In order to gain an understanding of the students understanding of goal setting and reflection some questions were asked in the Likert survey (Appendix D). The pre-survey data shows what the students' experiences were, as well as their attitudes toward goal setting. When surveyed 76% of the students said they set goals, however the type of goals that they set were very different. One of the open-ended questions asked what their goals were. All of the students that responded to this question had long term goals. The most common responses from students regarded success in high school, achieving a good college placement, good career, and performing well in athletics. None of the goals were shorter than a five year plan, some were more like 10 year plans. The strange thing was that only 11% of students felt that goals, should only be long term. If students mentioned short term goals most of them utilized lists or extremely simple goals. Multiple students shared that they utilize their assignment notebook for homework and due dates. Many students believed meeting the requirements of an assignment was considered meeting a

goal. While some students mentioned, “studying” as a short term goal. Other students mentioned short term health related goals like, “lose weight”, or “I want to bench 200 pounds” or “I want to score a goal for my soccer team.” The responses from students correlates with the goals of many of the parents for their student. A large focus of many high schools and high school students is on college and careers for the future. Students also receive some training in using lists and planners to stay organized, so these tools may be commonly used. Students are not likely to create goals that are medium length goals, a week to a year, because they never are taught that these goals can be important too.

Students’ opinions toward SMART goals, were collected, even though they might not have known they had opinions about SMART (Figure 6). When asked directly about the first three of these features 78%, 76%, and 80% of students responded positively respectfully. Their view on time sensitivity and the necessity of steps, is less affirming with 42% and 46% respectfully. The majority of students make some goals but did not use all of the SMART systems tenets. Most students saw the importance of goals but may have used them much more informally.

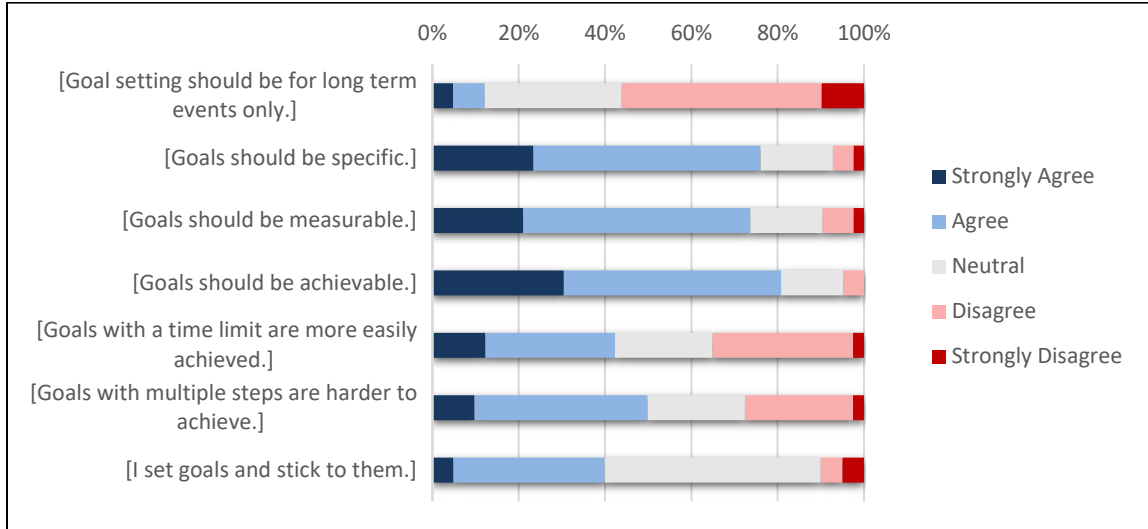


Figure 6. Students' initial views on goals, (N=78).

The next subset of questions is regarding success and students' opinions of learning (Figures 7 and 8). A large percentage of students, 92%, believe that all the resources they need to be successful are available to them and 90% believe getting help from a teacher would help them be successful. This shows that they realize the opportunities available to them for success and that their achievement can change.

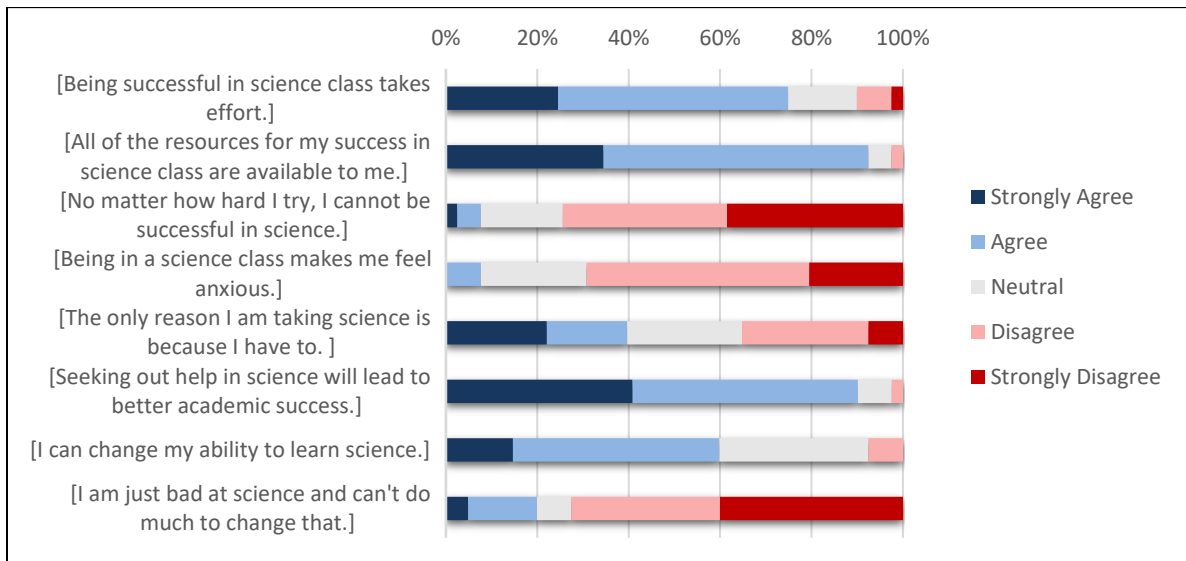


Figure 7. Students' views on learning and success towards science pre-study, (N=78)

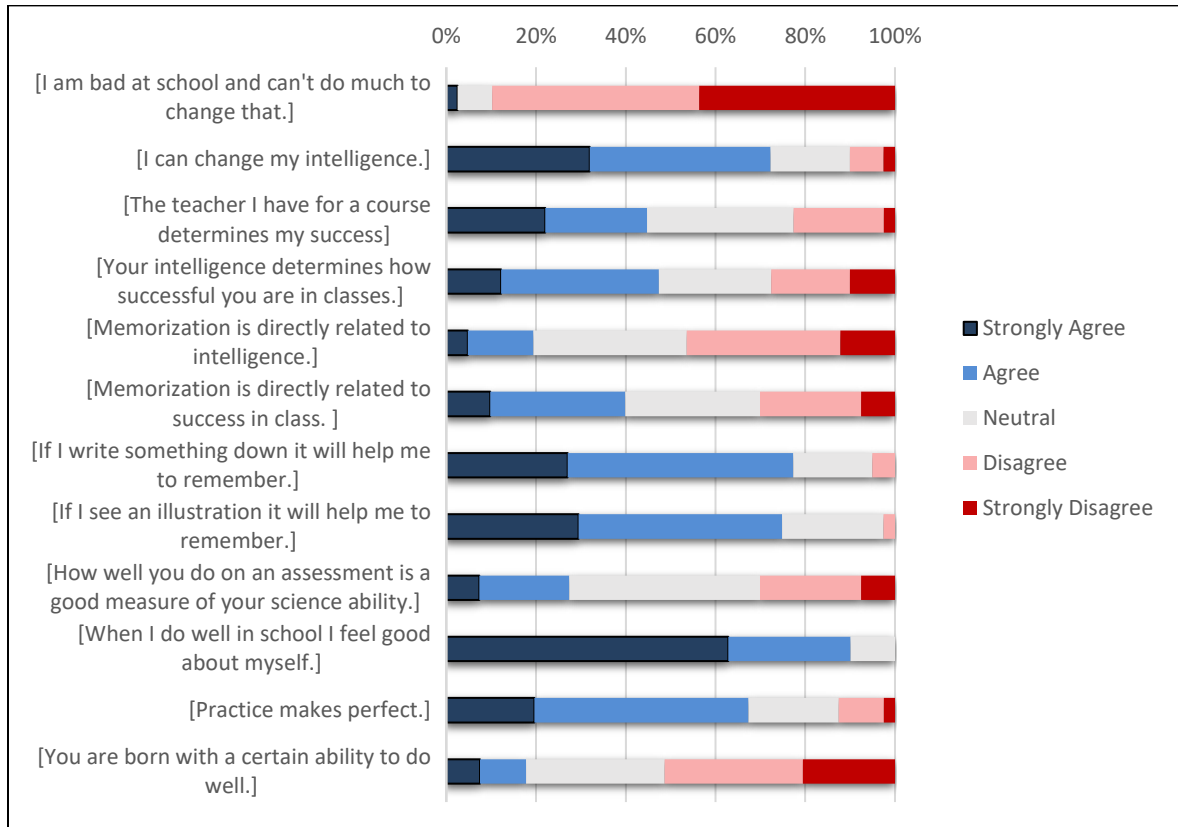


Figure 8. Students’ views on intelligence and learning pre-study, (N=78).

The Likert data from Figure 7 and Figure 8 was quantified and a mean Likert scale score for each set of prompts was collected. Table 2 shows the mean Likert scores for the two Likert scales pre and post-study. A p-value of 0.03768 for the Views on Learning and Success shows that there was a significant change in students’ attitudes towards success and how they feel toward science. This may be because students began to feel more comfortable in class, due to goal-setting in class.

Table 2
Mean Likert Scale Scores for Views on Learning and Views on Intelligence

Likert Scale	Pre-study	Post-study	Change	Significance (t-test, p-value)
Views on Learning and Success towards Science	3.52	3.68	0.16	Yes - 0.03768
Views on Intelligence and Learning	3.24	3.44	0.2	Yes - 0.0007685

In regards to fixed mindset versus growth mindset, most students seem to believe in growth mindset. Sixty percent of students said they believe they can change their ability to learn science. When asked if they are born with a certain ability/intelligence, 18% of students agreed. This number was high based on the previous questions. Only 2% of students said they can't change how they are doing in science class. It appears that most students believe in a growth mindset but also a little fixed mindset. Students mentioned that they can "work up to a certain level, but not everyone can be brilliant." This was a common response to what students thought about intelligence. Every student mentioned that you could "gain intelligence," however, the level varied. A few students mentioned that some people have "head starts" but anyone can catch up with "hard work." All of the prompts showed an increase toward a positive response individually and as a whole Likert scale. This showed a positive growth in student's self-efficacy.

Academic growth was collected by evaluating the differences between pre and post unit tests for both the non-treatment and the treatment units. Normalized gains were collected using the equation:

$$\text{Normalized gain} = (\text{Post-test score} - \text{Pre-test score}) / (100 - \text{Pre-test score})$$

The normalized gains were then evaluated using a t-test with the null-hypothesis that there was no significant change between the non-treatment and the treatment units. This allowed the growth within the units to be evaluated individually and then against each other. The raw percentage data is given in Appendix G. Using the raw data an average for the normalized gains was collected. For the non-treatment unit, an average normalized gain of 0.58 was expressed; and for the treatment unit, a 0.67 normalized gain was

collected. This was a statistically significant difference. According to a t-test comparing the normalized gains between the non-treatment unit and the treatment unit there is a p-value of 0.0002279. This low of a number shows that there was an extremely significant difference between the gains in the non-treatment and the treatment units. The utilization of goal-setting and reflection allowed students to focus on the small parts of the unit as well as the unit as a whole. They had to continually reevaluate what was going on during the unit and how they were progressing. Keeping their minds on the unit kept them focused on their academics.

INTERPRETATION AND CONCLUSION

The data collected in the pre-survey helped to shed light on the students' initial opinions of themselves, school, and goal-setting (Appendix D). This survey, given both pre and post-study, made up one half of the heart of the data interpretation. The other major component was the interpretation of the unit pre and post-tests (Appendices E and F).

Since the non-treatment and treatment units were controlled as best as possible, it can be assumed that a significant change between the non-treatment and the treatment unit would be the effect of the change administered in the treatment unit. In the case of this study, the change during the treatment was the SMART goal-setting and reflection process.

To answer the first question of the study; how does goal-setting affect self-efficacy and academic success, multiple data sets needed to be evaluated. After evaluating all the data at hand, there appears to be a positive effect from goal-setting and

reflection on self-efficacy and academic success. As stated in the data section there was a significant increase in the Likert scale data for self-efficacy from 3.53 to 3.68 with a p-value of 0.03768. Unit assessments, normalized growth was also used to compare the two units. A p-value of 0.000227 was observed for a t-test between the non-treatment and treatment unit's normalized gains.

I expected students to feel better about their learning and therefore be more successful on the assessments. By setting goals, students were able to stay organized and get a positive feeling of achievement. They also gained a feeling of control and choice over their actions. By choosing what was most important to them, they could direct their choices. Even when a student didn't meet their goal, the reflection process allowed for alterations. Students learned skills and they learned about themselves. The shared experience of goal setting with their peers also created an environment of trust and comfort. They could see what others were doing and thinking. All of these skills and feelings were gained through the goal setting process.

Academically, as shown in the conceptual framework, students that feel good will generally perform better. If a student is comfortable and believes they can do well, they will do well. This can create positive gains, although it doesn't mean everyone gets 100% on everything but that students will learn and grow. The students saw and felt this growth between the two units.

The survey data was evaluated for the question, How does a student's belief in how they learn (growth vs. fixed mindset) relate to their self-efficacy? As I mentioned previously, the Likert data and short answer responses showed that the vast majority of

students believe in a growth mindset. However, their understanding of growth mindset and fixed mindset may be limited since there was a big difference in responses between questions that directly asked about changing intelligence and learning something. Most students seemed to believe that learning can occur based on hard work. Some students said that there was a cap to the amount intelligence could increase.

Students' understanding and belief in growth-mindset shifted through the research and learning process. The Likert data showed that there was a significant increase between the pre and post survey data relating to learning. For the pre-study data there was an average Likert scale score of 3.24, and for the post-study Likert scale the average score was 3.44. After evaluating a t-test for the Likert data, a p-value of 0.0007685 showed that there was a significant change between the surveys. This showed that students now believe they can affect their learning, more than at the beginning of the semester.

VALUES

High school science and biology can be very important and may become the background for many students' careers, in the future. But for many students, the content and information learned in biology will become an afterthought when they walk out the door of the classroom. That is why it is extremely important for educators to help build well-rounded students. Focusing on science skills that can translate to other areas of a student's life is essential. Another strategy teachers can implement is helping students with life skills. Goal setting is a process that can be utilized by anyone at any time, no matter what their age or background.

It was great to see students owning their goals and striving to be successful. The vast majority of my students really enjoyed the goal-setting and reflection process. They felt invested and I am hopeful they took away a tool that they will use outside of class. I intend to continue implementing goal setting into my class for years to come. The bonding and trust built between myself and my students was extremely valuable. The data from Figures 3 and 4, regarding students' feelings toward science and biology, were mostly inconclusive. In the future, I plan on administering the Likert survey immediately upon the start of the school year (Appendix D). Then I can administer the survey throughout the year and actually see if there were significant changes in the students' opinions. I will also include more pointed questions regarding student likes and dislikes with science, biology, the class, and myself as a teacher. These surveys will become a great way to formatively assess myself and see what is working and what must be adjusted.

As I saw with the survey data, students learned a lot about themselves and built confidence in their ability to learn. This is something I want to help instill in all of my students in the future. I plan on incorporating more self-reflection and group discussions for the students. Students can then work through goals and issues individually and with their peers.

It will be interesting to compare this year's data to next year when I utilize goal-setting for both units used in this study. I will definitely be evaluating the normalized growth for the individual students between these same two units next year. I attempted to control as much as possible between the two units, but there were definitely still

differences, especially with the content. Sometimes later units are just easier because you have the foundation of previous units to build on.

Utilizing the action research process was extremely impactful for me. I learned a lot about evaluation of data. Prior to this action research I would use a lot of subjective data. Now I know some tricks of the trade to use when evaluating data. I also realize the importance of collecting lots of varied data through surveys, interviews, and other informal means. I will definitely be much more observant and deliberate with my data collection. Relating back to the study, I definitely have gained a higher self-efficacy because of this action research. I saw scientific and quantifiable growth in my students based on my decisions to try something new. Like always, I will continue to try new things and evaluate them to help my students become the best that they can be in all regards.

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APPENDICES

APPENDIX A
INSTITUTIONAL REVIEW BOARD EXEMPTION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Sean Michael Rauen and Walter Woolbaugh
FROM: Mark Quinn, Chair *Mark Quinn*
DATE: November 25, 2018
RE: "The Effect of Goal-setting and Reflection on Student Motivation" [SR112518-EX]

The above research, described in your submission of November 19, 2018, 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
SMART GOALS WORKSHEET

Name: _____ Date: _____

SMART Goal Worksheet

What is your goal?

Is your goal S.M.A.R.T.?

Specific: *Is your goal specific? Make sure it is not open-ended or ambiguous.*

Measurable: *How will you know when you have reached this goal?*

Achievable: *Do you believe that achieving this goal is realistic for you? Why do you think this?*

Relevant: *Why is this goal important to you? How does it relate to your life and your success?*

Timely: *When will you achieve this goal?*

Completion Date:

Planning for Success

Specific action steps. (Edit as needed)

Expected Completion Date

Completed (X)

List/Describe a few potential obstacles/struggles you foresee.

APPENDIX C

BEGINNING OF THE YEAR CLASS QUESTIONNAIRE

Beginning of the Year Biology Class Questionnaire

This questionnaire is completely voluntary. Answer each question as openly and honestly as you feel comfortable with. This information will not affect your grade or any academic standing. The information collected from this survey will be used for educational purposes by your teacher. Your names and personal information will be kept anonymous.

1. What Class and Period are you in?
2. What is your full name?
3. What name do you like to be called?
4. What was one highlight of your summer?
5. What's the best book you've ever read and why?
6. Finish this sentence: One of my favorite things is _____
because...
7. Finish this sentence: One of my least favorite things is _____
because...
8. If you could teleport to anywhere in the world this weekend, where would you go and why?
9. Rank your confidence in science [Rank 0-4, 0 = "I am terrible at science, I'll be lucky to pass", 5 = "Science comes natural to me, I'll get an A in this class with very little effort"]
10. Rank your confidence in school [Rank 0-4, 0 = "I don't do well in most of my classes, I'll be lucky to pass", 5 = "School comes natural to me, I'll get an A in this class with very little effort"]
11. Rank the following core courses from easiest to most difficult for you:
[English, Social Studies, Math, Science]
12. Have you ever used goal setting and reflection techniques inside or outside of school? If yes, what techniques did you use and were they affective?
13. Finish this sentence: Something you should know about me as a student is _____ because...
14. Finish this sentence: Something you should know about me as a person is _____ because...
15. What is your favorite animal and why?
16. What type(s) of music do you most enjoy, Why?
17. What are 1-3 of your all-time favorite songs?

18. Please let me know if there are any questions/concerns you have about School, this class, or us. We'll try to address them in the next few days.

APPENDIX D
STUDENT SURVEY

Student Survey

Read each statement carefully and choose the descriptor that best describes your feelings and behaviors. Try to be as open and honest as possible all responses are voluntary and will be used only for educational purpose. Your names and personal information will be kept anonymous. This information will not affect your grade or any academic standing.

[This survey will be administered on Google Forms, this is a transcript of the survey questions]

1. I like school
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
2. Why did you choose the response for question #1?
3. I am successful in school.
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
4. I try my best in school.
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
5. I am successful in school, even if I don't like the content.
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
6. I like to be challenged in school.
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
7. I like science.
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
8. Why did you choose the response for question #7?
9. I am successful in my science classes.
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
10. I understand what we are talking about in science.
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
11. I am interested in pursuing a career in science.
A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)
12. I have to put a lot of effort into my biology class.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

13. I seek out help when I am struggling in Biology class?

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

14. I like Biology class.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

15. Why did you choose the response for question #14?

16. I am successful in biology class.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

17. I try my best in biology class.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

18. I enjoy the activities we do in biology class.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

19. I am often confused in biology.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

20. I feel comfortable in biology class.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

21. I am interested in pursuing a career in biology (relating to medicine, nature, plants/animals, or other fields)

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

22. What career/careers are you thinking of pursuing after high school?

23. I record homework assignments so I don't forget.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

24. I make lists of things I need to do.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

25. I talk to one or more adults about my long-term life goals.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

26. I have someone I trust and can confide in.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

27. I have goals for my life.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

28. List a few goals you have here:

29. I have goals for high school.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

30. List any school goals you have here:

31. I have goals for my biology class.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

32. I can change my intelligence.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

33. I can change my ability to learn science.

A. (Never) B. (Occasionally) C. (About Half the Time) D. (Usually) E. (Always)

34. Biology is easy for me.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

35. Seeking out help in school will lead to better academic success.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

36. Being Successful in a science class takes effort.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

37. All of the resources for my success in science class are available to me.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

38. Being in a Science Class makes me feel anxious.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

39. No matter how hard I try, I cannot understand science.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

40. The only reason I am taking science is because I have to.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

41. Goal setting should be for long term events only.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

42. Goals should be specific.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

43. Goals should be measurable.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

44. Goals should be achievable.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

45. Goals should involve steps.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

46. Goals should have a time limit.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

47. If I set a goal with a time limit I am more likely to achieve it.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

48. If I set goals that take multiple steps to achieve them, I am less likely to be successful.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

49. I set goals and stick to them.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

50. I am just bad at school and can't do much to change that.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

51. I am just bad at science and can't do much to change that.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

52. I am just bad at biology and can't do much to change that.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

53. The teacher I have for a course determines my success.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

54. Your intelligence determines how successful you are in classes.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

55. Memorization is directly related to intelligence.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

56. Memorization is directly related to success in class.

A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

57. If I write something down it will help me remember it.
A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)
58. If I see an illustration it will help me remember.
A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)
59. How well you do on an assessment is a good measure of your science ability.
A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)
60. How fast you are on assessments is a good measure of your science ability.
A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)
61. When I am successful I feel good about myself.
A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)
62. When I do well in school I feel good about myself.
A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)
63. Practice makes perfect.
A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)
64. You are born with a certain ability to do well.
A. (Strongly Disagree) B. (Disagree) C. (Neutral) D. (Agree) E. (Strongly Agree)

APPENDIX E

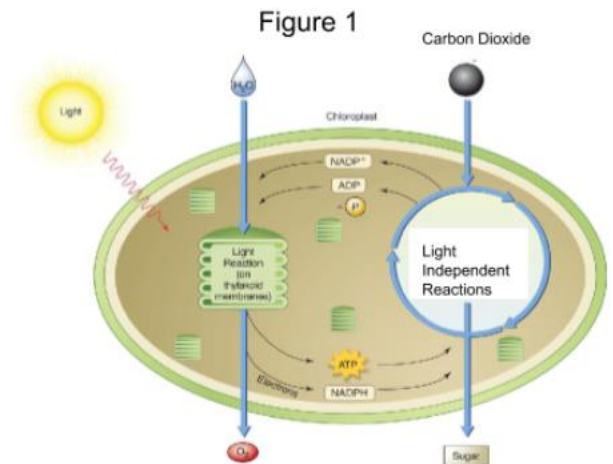
NON-TREATMENT UNIT PRE/POST ASSESSMENT

Photosynthesis Quiz

- In the light dependent reactions of photosynthesis, light energy is absorbed by:
 - chlorophyll which provides energy used to excite electrons.
 - water and given off as oxygen molecules.
 - carbon dioxide and given off as oxygen.
 - sugars and given off as energy.
- During photosynthesis, the oxygen atoms in water molecules
 - help form sugars.
 - help form water.
 - end up as oxygen gas.
 - help form both sugars and water.
- Light energy, during the light dependent reactions of photosynthesis, is stored as
 - Potential energy in the bonds of ADP
 - Potential energy in the bonds of ATP and NADPH
 - Potential energy in the bonds of NADP⁺
 - Kinetic energy in the bonds of ATP
- During photosynthesis, what will happen to the plant's production of glucose if there was **no** carbon dioxide available?
 - The production rate of glucose will lower
 - The production rate of glucose will not be affected
 - The production rate of glucose will increase
 - Glucose production in the plant will stop

Use Figure 1 for Questions 5 and 6.

- When viewing the light independent reactions the molecules ATP and NADPH fall into what category.
 - Products
 - Reactants
 - Catalizer
 - Inhibitor
- During which phase of photosynthesis does CO₂ serve as a reactant and sugar become a product?
 - Light reaction
 - Respiration
 - Light Independent Reactions
 - Electron transport chain



7. When water is removed from a plant, the plant will die. What best explains why plants can not live without water.
 - a. Without water plants cannot utilize oxygen
 - b. Water gives oxygen molecules that are used in the formation of sugar.
 - c. Water provides the electrons which are excited by sunlight

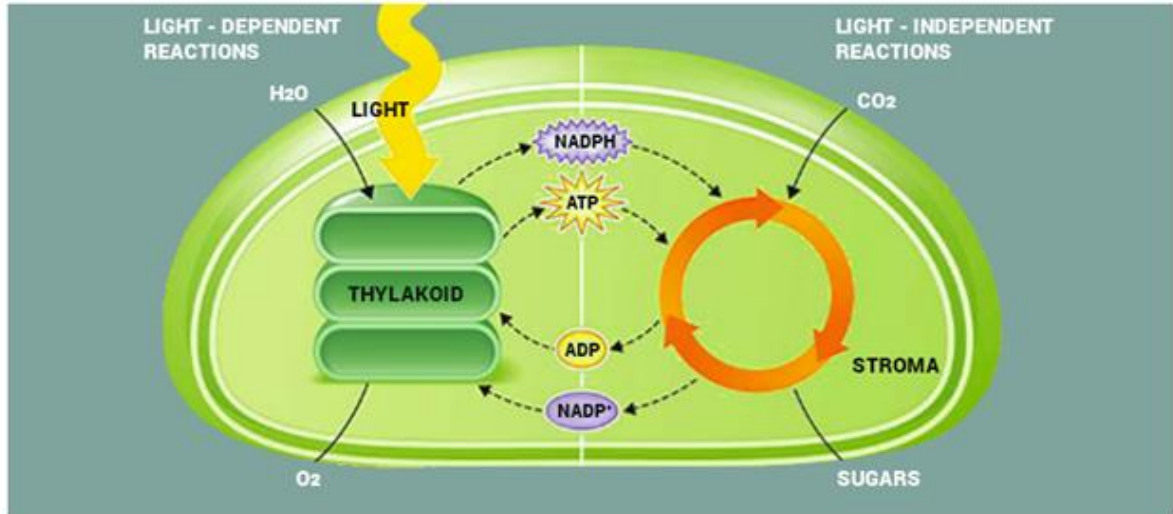
8. If the light reaction stopped why would the light independent reactions also cease functioning?
 - a. There would be no ATP energy source for the light independent reactions.
 - b. NADPH would no longer be produced and the light independent reactions would have no high energy electron to convert CO_2 into a sugar
 - c. There would be no oxygen produced
 - d. Both A and B

9. Which statement best describes the overall function of photosynthesis in any photosynthetic autotroph?
 - a. To directly produce energy for the plant's cells.
 - b. To produce sugar for the plant that will be later used to release energy.
 - c. To produce oxygen for the plant that will help humans and other animals.
 - d. To release electrons from water that will be used later during cellular respiration.

10. Where do plants get most of their mass?
 - a. The water absorbed in their roots
 - b. The CO_2 from the atmosphere
 - c. Glucose molecules from cellular respiration
 - d. Sunlight activating the production of ATP

Short Answer Section

Figure 2



11. List the reactant(s) and product(s) of a **light dependent** reaction. (2 pts)

Reactants:	Products:

12. List the reactant(s) and product(s) of a **light independent** reaction. (2 pts)

Reactants	Products

13. Describe the relationship between the light-dependent and the light-independent reactions that causes them to be dependent on each other. (3 pts)

14. What is the initial form of energy photosynthesis uses? (1 pt)

15. Describe two points during photosynthesis where energy changes forms.(2 pts)

Use the following passage and figures to answer questions 16 and 17.

A student prepared a beaker with sprigs of a water plant as shown below in Figure 3. She places the beaker beside a fluorescent lamp. She then systematically changed the distance the beaker is from the lamp. She then counted the bubbles of gas given off by the sprig of the water plant.

Figure 4 shows a graph of the data for the beaker in Figure 3, that was in the light.

Figure 3

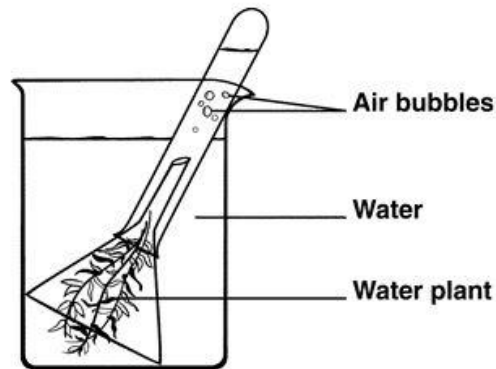
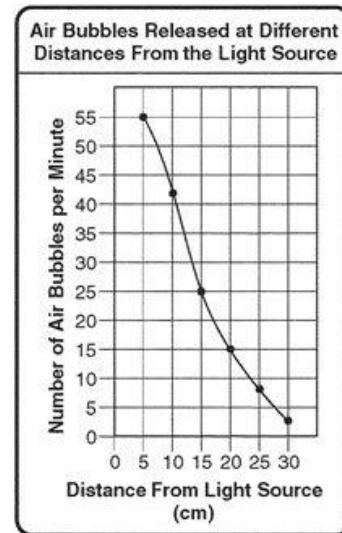


Figure 4



16. Using Figure 3:

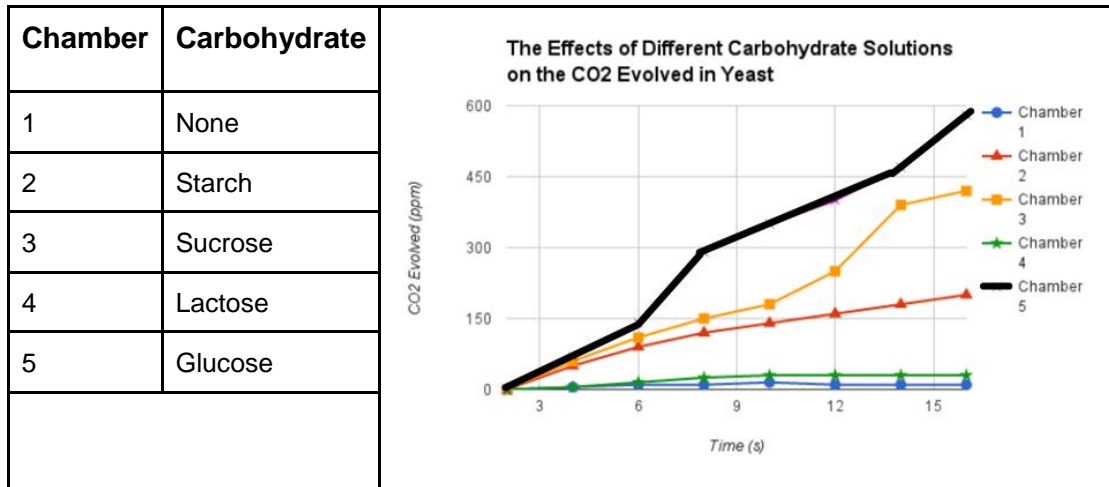
- Claim: What relationship was discovered from this experiment? (1 pt)
- Evidence: Support your claim using the **data** in the graph. (1 pt)
- Reasoning: Describe how the data supports your claim. (1 pt)

17. If the student later tested the bubbles collected in the test tube, what would she find they are made of? Explain how you know. (3 pts)

APPENDIX F
TREATMENT UNIT PRE/POST ASSESSMENT

Cellular Respiration Quiz

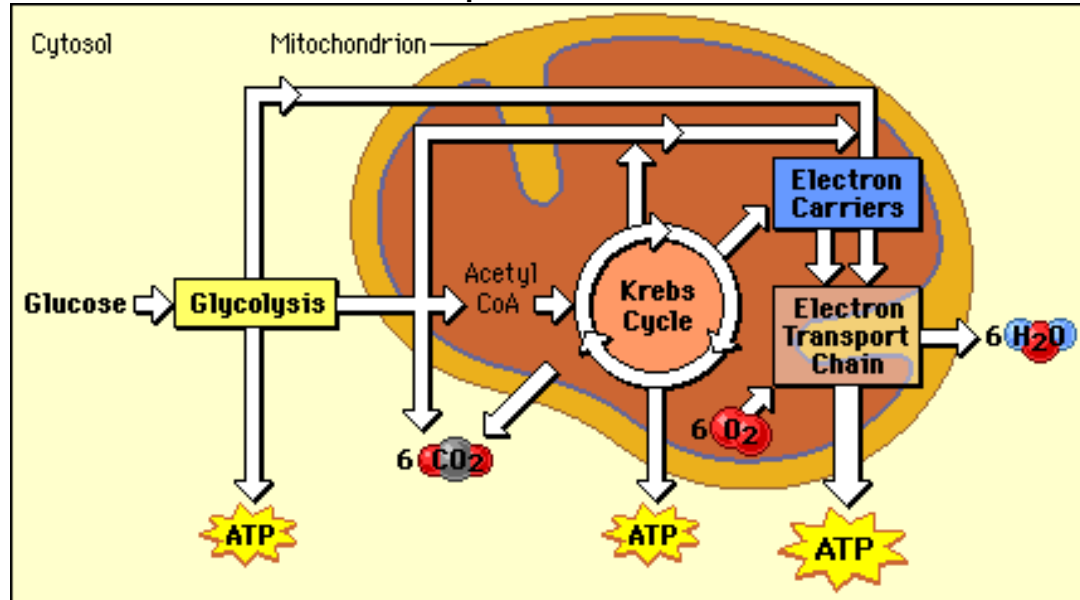
A biology student performed an experiment testing the effects of various carbohydrate solutions on the CO₂ respired from yeast cells. Use the table and graph below to answer the questions. All chambers contained: 5 mL of yeast solution, 5 mL of distilled water, and 5 mL of indicated carbohydrate solution (except the control group)



- What was the purpose of chamber 1 in the experiment set up by this student?
 - To determine the amount of respiration when smaller volumes of carbohydrate and yeast are present with a larger volume of water.
 - Control group to determine the amount of respiration with no yeast cells.
 - Control group to determine the amount of respiration with no carbohydrate.
 - Control group to determine the amount of respiration with no yeast or carbohydrate.
- Fructose is a monosaccharide with a similar structure to glucose. At 10 seconds, approximately how much CO₂ (ppm) would be present in a chamber containing fructose?
 - 650 ppm
 - 500 ppm
 - 400 ppm
 - 150 ppm
- According to the data above, which chamber had the highest rate of respiration?
 - Chamber 2
 - Chamber 3
 - Chamber 4
 - Chamber 5
- Which of the following supports your answer to the question above?
 - The chamber with the highest rate of respiration would produce the least CO₂.

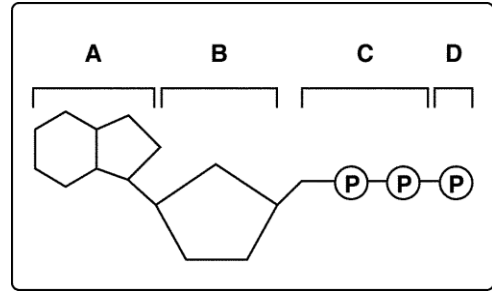
- b. The chamber with the highest rate of respiration would produce the most CO_2 .

Use the model below to answer questions 5-8:



- What is the equation for cellular respiration?
 - Water and Carbon Dioxide Glucose and Oxygen
 - Glucose and Water Carbon Dioxide and Oxygen
 - Glucose and Oxygen Carbon Dioxide and Water
 - Water and Oxygen Carbon dioxide and Glucose
- The majority of ATP in cellular respiration is produced by _____.
 - citric acid/Kreb's cycle.
 - electron transport chain.
 - glycolysis.
 - Equal amounts of ATP are produced during each of these.
- The energy within the bonds in glucose flows through the process of cellular respiration to be stored in what molecule?
 - ATP
 - Water
 - Sugar
 - CO_2
- The oxygen consumed during cellular respiration is involved directly in which process or event?
 - Accepting electrons at the end of the electron transport chain
 - Glycolysis
 - The citric acid/Kreb's cycle
 - The breakdown of pyruvate to CO_2

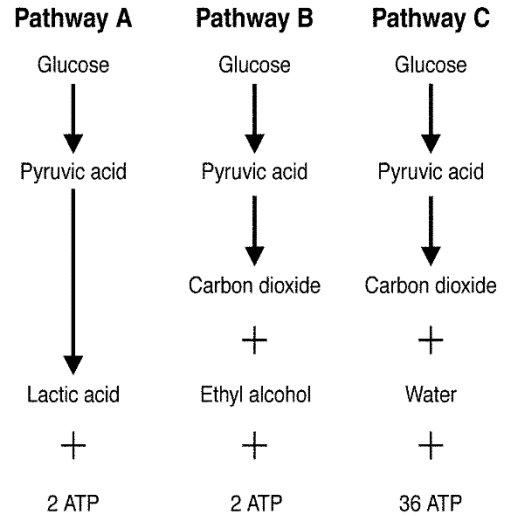
9. Which of the segments in the molecule picture to the right are part of an ADP molecule?



Select All That Apply

- a. A
 - b. B
 - c. C
 - d. D
10. How is energy released from an ATP molecule?
- a. Phosphate group is added
 - b. Phosphate group is removed
 - c. Adenine group is added
 - d. Adenine group is removed
11. Which of the following explains one reason that your muscles burn during anaerobic exercise?
- a. You are running out of carbohydrates, so your muscles are being broken down for energy.
 - b. You have no oxygen, so your muscles can't digest food and are starving.
 - c. You are undergoing fermentation and alcohol is accumulating in the muscles.
 - d. You are undergoing fermentation, and lactic acid accumulates in the muscles.

12. In the **figure to the right** which pathway would NOT be utilized by the human body?



- a. Pathway A
 - b. Pathway B
 - c. Pathway C
 - d. Pathway A and B
13. In the **figure to the right** which pathway would occur without the presence of oxygen?
- a. Pathway A
 - b. Pathway B
 - c. Pathway C
 - d. Pathway A and B

Short Answer Section

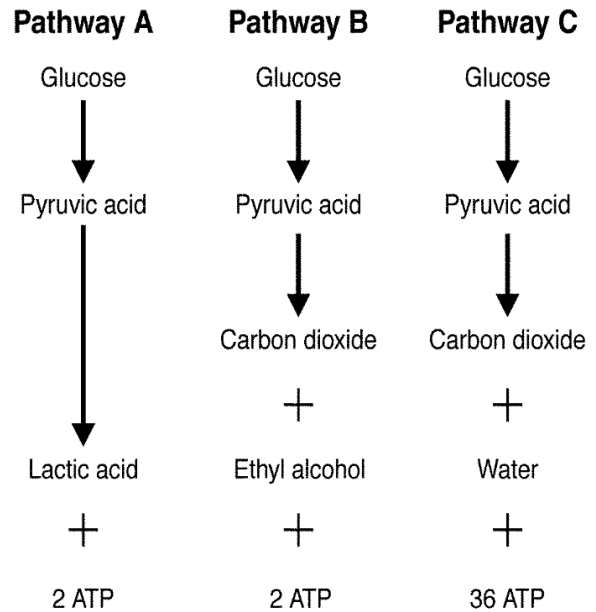
14. Using the diagram to the right:

a. Make a **claim** stating which pathway produces the most energy. (1 pt)

b. Provide **evidence** from the diagram to support your claim. (1 pt)

Respond to the three questions below for your **reasoning**.

c. Identify and describe the scientific concept illustrated in this diagram. (1 pt)



d. Under what conditions (aerobic or anaerobic) does this process occur? (1 pt)

e. How does this scientific concept connect the evidence to the claim? (1 pt)

15. Describe how matter is rearranged in the process of cellular respiration. Trace the path of oxygen OR carbon through the reactions of cellular respiration. Be sure to answer each component.

a. What atom are you tracing? (oxygen or carbon) (1 pt)

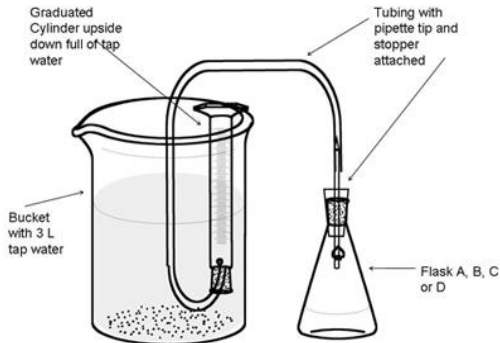
b. Which molecule is your atom initially part of? (1 pt)

c. When and where do changes occur to your initial molecule? (1 pt)

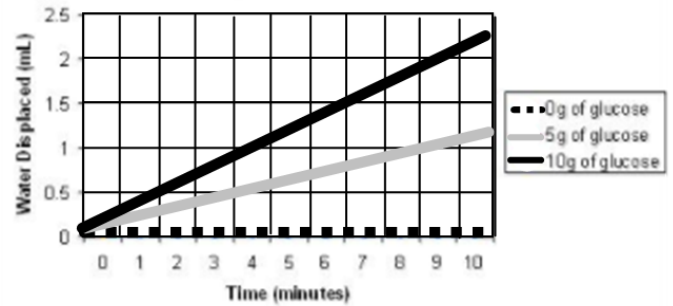
d. What product of cellular respiration is your atom part of? (1 pt)

Read the following paragraph and study the figures. Use the information from both to answer question

A student designed and conducted an experiment to determine the amount of gas produced by yeast in the presence of varying concentrations of glucose. The set-up consisted of a hose leading from an Erlenmeyer flask to an inverted graduated cylinder submerged in a bucket of 3 L of tap water. The three Erlenmeyer flasks each contained 10 grams of yeast as well as varying concentrations of sugar; 0 grams, 5 grams, and 10 grams. As the yeast used the sugar they produced gas, the gas would travel to the graduated cylinder and displace the water. This would allow the student to collect data on the amount of water displaced as a result of the gas production.



An Illustration of the Effects of Glucose on the Cellular Respiration of Yeast as Shown by Water Displacement over Time



16. Based on the experimental setup above and the graph with data,
- Make a **claim** about the effect of sugar concentration on gas production. (1 pt)
 - Support your claim with two pieces of **evidence** using quantitative data provided. (2 pts)

Respond to the three questions below for your **reasoning**. (3 pts)

- Identify and describe the process illustrated in this diagram.
- What gas is being collected in the inverted graduated cylinder? (1 pt)
- Why is gas production a good indicator of the effect of sugar on this process? (1 pt)

APPENDIX G
PRE/POST UNIT ASSESSMENT DATA FOR NON-TREATMENT AND
TREATMENT UNITS

Non-treatment Unit				Treatment Unit			
Pre-test	Post-test	Percent Change	Normalized Gains	Pre-test	Post-test	Percent Change	Normalized Change
84	100	16	1	84	100	16	1
82	100	18	1	83	100	17	1
80	100	20	1	80	100	20	1
80	96	16	0.8	83	96	13	0.7647059
80	93	13	0.65	80	93	13	0.65
78	97	19	0.8636364	78	97	19	0.8636364
78	92	14	0.6363636	77	92	15	0.6521739
76	88	12	0.5	73	93	20	0.7407407
76	89	13	0.5416667	79	94	15	0.7142857
74	85	11	0.4230769	73	97	24	0.8888889
72	93	21	0.75	78	92	14	0.6363636
72	88	16	0.5714286	73	96	23	0.8518519
72	83	11	0.3928571	71	92	21	0.7241379
70	89	19	0.6333333	70	92	22	0.7333333
68	94	26	0.8125	66	94	28	0.8235294
68	94	26	0.8125	66	94	28	0.8235294
68	93	25	0.78125	63	93	30	0.8108108
66	96	30	0.8823529	68	96	28	0.875
64	92	28	0.7777778	65	92	27	0.7714286
64	98	34	0.9444444	64	98	34	0.9444444
64	84	20	0.5555556	64	88	24	0.6666667
64	83	19	0.5277778	64	86	22	0.6111111
64	85	21	0.5833333	62	87	25	0.6578947
62	84	22	0.5789474	67	89	22	0.6666667
62	86	24	0.6315789	68	77	9	0.28125
62	89	27	0.7105263	69	88	19	0.6129032
62	86	24	0.6315789	69	84	15	0.483871
62	85	23	0.6052632	63	88	25	0.6756757
60	78	18	0.45	62	89	27	0.7105263
60	85	25	0.625	60	90	30	0.75
58	76	18	0.4285714	60	92	32	0.8
58	79	21	0.5	60	89	29	0.725
58	73	15	0.3571429	60	90	30	0.75
58	84	26	0.6190476	58	92	34	0.8095238
58	82	24	0.5714286	54	93	39	0.8478261
56	84	28	0.6363636	59	88	29	0.7073171
56	85	29	0.6590909	58	90	32	0.7619048
56	86	30	0.6818182	57	90	33	0.7674419
54	88	34	0.7391304	56	92	36	0.8181818
54	75	21	0.4565217	60	86	26	0.65
54	79	25	0.5434783	63	88	25	0.6756757
52	82	30	0.625	65	82	17	0.4857143
52	75	23	0.4791667	68	83	15	0.46875

52	73	21	0.4375		58	89	31	0.7380952
50	78	28	0.56		60	90	30	0.75
50	79	29	0.58		62	78	16	0.4210526
50	78	28	0.56		62	88	26	0.6842105
48	75	27	0.5192308		57	82	25	0.5813953
48	72	24	0.4615385		54	88	34	0.7391304
46	82	36	0.6666667		56	83	27	0.6136364
46	68	22	0.4074074		58	85	27	0.6428571
46	77	31	0.5740741		52	86	34	0.7083333
44	79	35	0.625		52	87	35	0.7291667
42	83	41	0.7068966		52	88	36	0.75
42	90	48	0.8275862		48	83	35	0.6730769
40	68	28	0.4666667		46	90	44	0.8148148
40	66	26	0.4333333		49	82	33	0.6470588
38	76	38	0.6129032		60	81	21	0.525
38	64	26	0.4193548		48	81	33	0.6346154
36	63	27	0.421875		48	80	32	0.6153846
36	54	18	0.28125		50	77	27	0.54
34	64	30	0.4545455		32	77	45	0.6617647
34	66	32	0.4848485		54	70	16	0.3478261
32	45	13	0.1911765		44	72	28	0.5
32	58	26	0.3823529		48	72	24	0.4615385
32	66	34	0.5		45	68	23	0.4181818
30	70	40	0.5714286		44	68	24	0.4285714
30	68	38	0.5428571		41	68	27	0.4576271
28	70	42	0.5833333		38	77	39	0.6290323
28	68	40	0.5555556		38	73	35	0.5645161
28	66	38	0.5277778		38	72	34	0.5483871
26	62	36	0.4864865		39	72	33	0.5409836
26	54	28	0.3783784		40	74	34	0.5666667
24	48	24	0.3157895		42	68	26	0.4482759
24	44	20	0.2631579		26	68	42	0.5675676
22	68	46	0.5897436		22	78	56	0.7179487
20	66	46	0.575		27	72	45	0.6164384
20	62	42	0.525		28	71	43	0.5972222
52.30					57.92	85.384		
8	78.5	26.192	0.5827977		3	6	27.462	0.6735018