

THE EFFECT OF A SCIENTIFIC READING CURRICULUM ON OVERALL  
PERFORMANCE AND ATTITUDE IN HIGH SCHOOL STUDENTS

by

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## ABSTRACT

There is a growing influence of technology on scientific learning, with primary focus on learning in an online environment. This has both benefits and challenges, but in the science classroom, a primary challenge is being able to read the required material effectively on your own, and then productively present that material in class discussions and on assessments. While this is a well-developed skill in the humanities, it is not a primary focus of instruction in a typical high school science classroom of approximately 15 students. The primary question I sought to answer with this study was what the effects of implementing and testing some reading comprehension strategies on high school students would have on their ability to retain information on tests, their performance on daily quizzes, and their confidence level in the classroom. Four academic units in a high school Biochemistry course were studied, and progressed in the order of the Digestive System, Vitamins and Minerals, Exercise Physiology, and Immunology. Understanding of concepts was assessed using student-developed concept maps, and overall interest and participation was assessed by anonymous surveys, and one-one-one student-instructor interviews. While overall test and quiz scores increased only very slightly throughout the intervention, class participation increased and student interviews reflected a positive increase in confidence and quality of thought in the science classroom.

## INTRODUCTION AND BACKGROUND

Students at Blair Academy have a fear of reading science textbooks and articles, which is likely due to inefficiency in the instruction of proper techniques in reading science texts. Since there is no formal curriculum to support this, and each teacher emphasizes the text book differently, there is a gap between teacher expectations and student understanding. According to Yore (2006), “science textbooks are dominant influences behind most secondary science instruction but little is known about teachers’ approach to science reading” (Yore, 2006). To improve this, more structure and focus on effective reading was infused into the classroom to see if the students gained more confidence in their ability as well as retained the course information better in the long term. According to Yore, most teachers have an expectation for their students to use particular science texts, however the grand majority are providing no specific instruction as to how to do that. He also states that of the required skills necessary to read science text, comprehension is the area that students are most deficient in. Finally, Yore states that a disconnect exists between the writers of these textbooks, which are often written for the college level, and the educators that are implementing them in the classroom. This lack of communication has contributed to the ineffectiveness of textbook use in the science classroom greatly (Yore, 2006).

Blair Academy is an independent boarding school in New Jersey, with 450 students from all over the United States and the world. It is co-ed, and students are required to take three years of science, including one life science, one physical science, and two lab sciences. Typical class sizes average around 12 students, and classes meet four times a week for 55 minute periods. The representative student takes some level of

each of the following courses, Biology as a freshman, Chemistry as a sophomore, Physics as a junior, and either an Advanced Placement science or an elective course as a senior. There are certainly exceptions to this schedule, depending on the capabilities of the student and the availability of the course selections, however approximately 75% of the student body follows this track. There is no state-mandated testing because it is an independent school, so there is much autonomy in each classroom. This gives us, as educators, the freedom to cover topics we feel are relevant, not necessarily teaching to a test, with the exception of the Advanced Placement courses. Due to this autonomy, there is no formal curriculum, and each teacher, or group of teachers, works to develop one for each individual course. While this is a very attractive quality because it gives each teacher a sense of ownership on their classes, it does create some level of inconsistency on certain fundamentals, such as effective reading of science textbooks and journal articles. In the boarding environment, the role of the faculty is quite unique, in that we must proctor the students in the evening while they are working on their homework. This gives huge insight into the struggles they encounter on a daily basis, and I was able to observe them struggling particularly with reading comprehension in the science classroom. When students were assigned reading for homework, I witnessed a sense of fear and inadequacy in their approach, often causing students to give up before finishing the assignment, or not even attempt to complete it. Obviously, each textbook and each subject has a different level of depth and a different style of presenting information, but it seems to be a common trend that the majority of science students at Blair Academy are not benefiting from texts as well as they could and the teachers are not being consistent in using the text in the classroom.

High school students are at a disadvantage going on to college without learning to read a scientific textbook or journal article with confidence retaining the ability the information they read. Moats (2007) stated that:

U.S. reading scores have been too low for too long. Consider the National Assessment of Educational Progress (NAEP). Since 1992, its results for reading by fourth and eighth graders have been almost uniformly bleak. Among fourth graders, just 31 percent of students in 2005 rated proficient or better. That's just two points higher than in 1992. The exact same scores were recorded by eighth graders over the same time span. For at least a decade and a half, in other words, despite standards-based reform, despite No Child Left Behind (NCLB), America has failed to significantly improve the percentage of its children who can read at levels that will enable them to compete in higher education and in the global economy (p. 6).

Though those data deal with younger students than I teach, the concept remains the same. As a college preparatory school, I feel that we have the responsibility to educate students on how to do this effectively in order to give students the best chance at success in college and beyond. At Blair Academy, there is no requirement or curriculum that supports this education, so it is up to the individual teacher to implement a structure suitable to each course. Particularly in the upper school (11<sup>th</sup>-12<sup>th</sup> grade), students are required to write research papers and outline textbook pages, however many of them have never properly learned how to read and comprehend scientific literature, and therefore their grades suffer, both on individual assignments and long term retention of material, and lack the confidence and experience to make the most of their high school science

education because they have only been instructed in reading material in the humanities. More instruction and guidance in scientific reading will improve student perception and student performance in the science classroom.

### CONCEPTUAL FRAMEWORK

Reading scientific literature is a unique skill, but it begins with basic reading comprehension, just like any subject. With many teachers, particularly those that focus on one subject, basic reading comprehension skills may not be at the forefront of their teaching. In particular, reading science texts requires an understanding of technical vocabulary and an ability to use diagrams and formulas in addition to the written text (Yore, 2006). Students have been shown to perform better when the subject of the readings are more content based and relevant to a particular lesson or historical event that they are aware of, such as learning about metabolism by discussing Diabetes, a common disease that they have likely encountered, giving them a more realistic example to learn from (Jarman and McClune, 2005). Proper instruction on reading comprehension is a valuable skill in preparing students for the world outside of high school (Spencer, 2011). The environment students are in plays an important role in their level of understanding and the enthusiasm with which they approach their learning (Bolling and Evans, 2008). Students need to learn the skills involved in reading comprehension, and then be given the time and materials to read through the texts and attempt to comprehend the main ideas and relevance of each assignment (Heibert, 2009). While this is often taught in the typical English classroom, applying these same concepts in other subjects has shown promise (Spencer).

Teachers use science textbooks for a variety of reasons, but the overwhelming use seems to be as a supplement to the classroom lectures and activities, primarily outside of class time. It is a sort of glossary of terms that they can refer to if they are confused about a topic and a chance for students to move ahead in the curriculum if they desire. However, according to Fredricks (2005), “a textbook is only as good as the teacher who uses it”, and textbooks have limitations in their ability to convey material, such as being outdated, at too high a reading level, and not factoring in the student’s background (Fredricks, 2005). In a study performed by Driscoll, Moallam, Dick, and Kirby (1994), this concept of using the book to learn the course material independently proved ineffective, with middle school students averaging a test score of 59% on strictly vocabulary from the book, much lower than the control group because the control group was able to use additional resources, such as supplemental readings and instructor assistance (Driscoll et al.). Since science textbooks can be poorly written and too complex, some teachers will avoid using them, however if students are instructed on how to read through them effectively, they may be more productively used in the classroom (Radcliff, Caverly, Peterson, and Emmons, 2004). Radcliffe, Caverly, Peterson, and Emmons (2004) used student pre and post-tests, as well as student interviews to assess the success of a technique called the PLAN technique (Predict-Locate-Add-Note) in the middle school science classroom. While the material covered with this method was no different than in a traditional lecture format, with the altered approach from the instructor using the PLAN technique, the perception of the class changed and some benefit was found to using the textbook when the students were guided properly. No major increase in test scores was found; however the students demonstrated a higher order of thinking

with their concept maps and an increase in the paraphrasing of definitions from the textbook, rather than copying word for word responses (Radcliff et. al).

Interweaving reading assignments into the normal science curriculum is a way to achieve an increase in reading comprehension skills and student participation in class. It should not be a separate entity, but rather a technique used to develop and expand on content being covered in the class. Thelen (1976), states the following:

Reading instruction in science means to teach simultaneously the science content and the reading and reasoning processes by which that content is learned. The reading taught in the science classroom is the reading that is required by the curriculum. Science teachers can teach their students how to read required materials as needed. (p. 6)

The reading comprehension of secondary school students in all areas of study appears to be declining in recent years due to lack of reinforcement and proper instruction in every classroom. According to Bolling and Evans (2008), “To reverse this downward spiral, researchers have stated that these students need strategic reading instruction from competent, caring, and qualified teachers to improve their reading and comprehension skills” (p. 59). Bunce, Flens, and Neiles (2010) performed a study demonstrating that the first five minutes of any lecture and the last five minutes are when students show the least ability to stay attentive, so giving students a task right at the beginning of class, such as a short reading assignment, could be a way to gain that attention back and gear it more towards the material that will be discussed later in the class period.

Implementing scientific reading education in the classroom becomes the next challenge, and there are several methods that have proven successful of late. A recent

study by Radcliffe, Caverly, Hand, and Frank (2008) on Middle School Science Students showed that for reading textbooks, The PLAN (Predict-Locate-Add-Note) technique displayed promise, where students used concept maps to make predictions about excerpts in text, finding key terms, and summarizing main ideas in the classroom setting. An example concept map is shown in Figure 1 (Caverly, 1995).

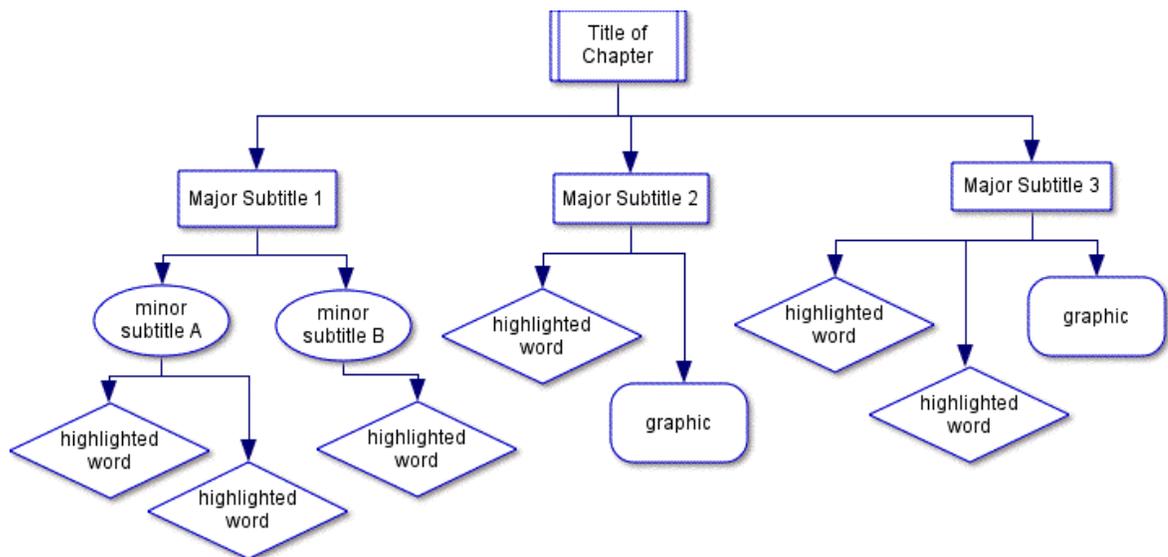


Figure 1. PLAN concept map example (Caverly, 1995).

Another strategy called CAIM (cognitive apprenticeship instructional model) mimics the process that many working professionals' experience and gives students the chance to relate a particular reading to a more relevant situation, such as a potential job in their future (Kolikant, Gatchell, Hirsch, Linsemeier, 2006).

Moreau (1999) proposed a basic technique to scientific reading among a group of nursing students, that consisted of a three part process, including an overview by the instructor, a quick read by the student for superficial content, then finally a longer more comprehensive read for content, which showed positive results in the retention of material by the students (Moreau, 1999). While this may seem simple, if it is coupled

with a guided inquiry, such as the PLAN method, it may improve the science classroom experience for students. While methods for scientific reading have dated back over a hundred years, many of the same principles are used, such as organizing information and color-coding different types of text (Laird, 1924). Advancements have certainly been made, but getting back to what worked historically, is a good strategy when approaching scientific reading. Processing scientific information from a textbook or a journal article is certainly not a new concept, however the amount that students are expected to read and the instruction on the process certainly is.

While there are several quantitative techniques available to attempt to assess scientific reading comprehension, such as tests, quizzes, and classroom participation, a much more intangible concept is often left out – the overall attitude of the student towards scientific learning, which in my experience is negative. Student surveys are crucial when trying to gain insight into this notion, but faculty methodology is equally important. Most teachers claim to use the textbook frequently in science courses, but they drastically vary in their level of requirement and time spent on educating students in proper technique (Yore, 2006).

In a recent study by Concannon-Gibney and McCarthy (2012), the instructional model of Do-Read-Do was implemented with some success in teaching students how to read science literature effectively. Seven teachers, ranging in experience and age, in a school on Long Island were part of the study which had students investigate a topic as an entire class (Do), then break into small groups or individuals to read more closely (Read), and then finally implement the new knowledge as an entire class (Do). Teachers were first instructed in how to use this process, then were able to implement in their own

individual classrooms, allowing them to move away from classic interrogation teaching and more toward developing comprehension strategies. Using a model like this at the beginning of classes could help to alleviate the lack of attention seen in the first few minutes of class time, while also breaking up the lecture with small tasks and group work. The difficulty in this method lies mainly in the initial resistance from students in learning a new technique while also having trouble working effectively in groups on a regular basis (Concannon-Gibney, McCarthy, 2012).

Overall, the research studied suggests that reading science text is a necessary skill, and proper instruction on reading comprehension can not only improve the ability to process and reproduce information, but also improve confidence in the student, both in the classroom and outside of it. Particularly in the science classroom, students are often overwhelmed with course content and how it is presented. Being able to comprehend complex terminology, while also analyzing data and figures, would be an asset to most science students both in performance on tests and on classroom participation during class discussions.

## METHODOLOGY

The focus of this intervention was to improve both the effectiveness of reading in the science classroom on student performance in a science course and to assess overall student attitude towards science reading.

### Participants

The course chosen for this intervention was an upper-class science course that is designed to prepare students for collegiate level courses. In this Biochemistry course at Blair Academy, there were 14 students (6 females and 8 males) from various

backgrounds, including three international students (from South Korea, Bermuda, and Hong Kong), and a mixture of three 11<sup>th</sup> graders and eleven 12<sup>th</sup> graders. Seven of the students were taking another science course concurrently, either an Advanced Placement course, Physics, or another elective science (Marine Science, Environmental Science, or Engineering). As Biochemistry is also an elective course, it draws students from a variety of academic backgrounds. Some students had taken honors level Biology and Chemistry courses, while others had followed a regular track or took courses in a different order, having transferred from other schools.

### Intervention

My project was implemented over a period of eight weeks, beginning after the semester break in January of 2013 and ending before the spring break in March 2013. At the start of the intervention, students were assigned a reading from either their textbook or a supplemental reading, such as a journal article regularly for homework. This was complemented by daily lectures on the content of each individual unit. Instruction on how to process reading material was provided by group work, where students attempted to create concept maps, such as in Figure 1, and then had the opportunity to ask questions. Each Monday, the students began class with a short explanation or review of a topic, followed by a brief reading assignment in more depth, then they re-grouped as a class to answer a series of questions to test their comprehension. These questions were not graded, but rather used as a guide for the students to see if they were retaining the desired information from the reading. A short discussion followed and the students were able to ask questions or raise concerns about the assignment. This process followed the

“Do-Read-Do” method discussed earlier, and was intended to show that with a small amount of prior knowledge, students will retain the content much more effectively.

At least once during each academic unit, the students were assigned a reading in class and asked to use the PLAN technique to create a concept map that accurately represented the content in the readings. First, they predicted the content of each reading based on title, subtitles, and graphics and began to create a concept map. Then, they identified information that was known or unknown by placing a check or question mark next to that information. During the reading, students then added words and phrases that answer the unknown questions and help to confirm the known information. Finally, at the conclusion of the readings, students made any modifications to the concept map and discussed any differences with their peers. While this was designed to be an inquiry-based learning technique driven by the individual student(s), performing this in the classroom gave the students the opportunity to ask questions and receive feedback from the instructor when needed. Again, these assignments were not grades, but rather used by the instructor to judge progress with this process.

Throughout the rest of the week, the students were assigned 1-2 reading assignments for homework, to be completed on their own, outside of class time. Again, these were portions of the textbook or articles pertaining to the unit being covered, or a medical case study designed by the teacher. Students were then required to take a short quiz on the reading that night. These quizzes were posted online through a program called QuizStar, and allowed the students access for up to 24 hours. However, once a student logged in, they were only provided 60 minutes to complete the quizzes. While there was no way to prevent students from collaborating on these quizzes, by

implementing these time restrictions, it certainly hindered that, as well as encouraged the students to investigate the document ahead of time to ensure they had enough time to process the questions. These quizzes consisted of 5-10 questions, including some combination of multiple choice, fill-in the blank, and true/false questions and were designed to take each student approximately 10 minutes, had they performed the reading in advance. The questions attempted to lead the students in a manner much like the PLAN method described earlier, but by having them online, it made compiling the information easier for the instructor and also gave the students instant feedback on their answers.

The readings were content from the first 4 units of the second semester, the Digestive System, Vitamins and Minerals, Exercise Physiology, and Immunology. Textbook readings were taken from two primary sources, Gropper, Smith and Groff's (2009) Advanced Nutrition and Human Metabolism and Moran, Horton, Scrimgeour, and Pery's (2008) Principles of Biochemistry, 5<sup>th</sup> edition. Case studies were created by the instructor from a variety of sources, and were based on a disease related to a particular unit. An example case study can be found in Appendix C.

The unit test scores of the students were also tracked and compared to those from the previous academic year. In the fall of 2012, material was presented primarily in lecture fashion with a few supplemental readings in the biochemistry course. No additional instruction was given, therefore providing a control for this intervention. Scores were also compared to data from the 2011-2012 school year, which provides an interesting comparison because although the students were different, the content was the same, however presented in the more traditional lecture method. Though the students

were different, the sampling was similar with 15 students (8 female and 7 male).

Together, these two data collections gave a control of both the content presented and the students involved.

### Data Collection Instruments

Data collection included the quizzes discussed above, following each of the homework readings assigned. An example reading and quiz can be found in Appendix D, *Your Digestive System and How it Works*. The quizzes were “open” for 24 hours at a time and had a 60 minute time limit once they began. The program QuizStar automatically compiled the data from each student and allowed immediate feedback for both me and the student. Though the internet was required for these assignments each night, in the boarding school environment that was not an unreasonable request, as the internet is provided for each student 24 hours a day and controlled by the school.

These quizzes were graded as a homework assignment and calculated into their overall average with all other assignments. The idea was that taking these quizzes would give students a better understanding the material required for the course, while also providing them with some practice questions, similar to those they would see on a unit test. To see if these assignments had an effect on unit test performance, the following methods of data collection took place.

Test scores before and after intervention were collected and analyzed to look for any signs of improvement, particularly in sections requiring an analysis of a reading. While the content was certainly different and the assessments were from different units, the student population was the same, giving some basis for comparison. After intervention, data was collected over the course four units, or four tests, and then

compared to both last year's class tests on the same units, and to test averages from the fall semester to see if any improvements were made.

In addition to test scores, anonymous student surveys were given throughout the intervention in order to track student morale and excitement about the topics being covered in the class and the confidence level in reading scientifically. A baseline survey (Appendix A) was given before any assignments were given, and then a survey at the end of each unit (Appendix B) covered was given to assess the status of their progress. Finally, a survey at the end of the intervention was compared to the pre-intervention survey to see if there was any difference in the students' feelings towards their scientific reading assignments. The surveys consisted of a 5-point Likert Scale style of questioning, giving students a range of answers (strongly agree, agree, neutral, disagree, strongly disagree), looking for students to assess their background in scientific reading, their previous instruction in scientific reading, and their overall feeling about their ability to read scientifically and confidence in that ability. These surveys were done through Google Forms, which collected and compiled data from the surveys anonymously via the internet.

Student interviews were conducted at two separate points throughout the intervention, before and after; in order to get a better perspective from the students and allow them to put into their own words the frustrations and limitations they had with scientific readings and the ability of these assignments to alleviate those frustrations and limitations. Six students were selected based on class demographics, including a balance of gender and success in the course, as well as a willingness to participate. The pre-intervention interviews were short (approximately 10 minutes) and included just a few

questions, assessing their background in reading education, both in and out of science courses, and the potential effectiveness of implementing a strategy to help that process (Appendix E). They also addressed student feelings associated with the science classroom, particularly self-confidence and positivity. The post-intervention interviews asked similar questions but included the effectiveness of the intervention process (Appendix F).

Lastly, instructor observations recorded during the intervention period (and in the weeks before) to look at the number of students participating in class discussions and the number and quality of questions that were asked during the weekly discussions on scientific reading. This was simply a log of the number of student questions, followed by a ranking of quality of question by the instructor on a 1-3 scale (1 being elementary questions, 2 being questions with some depth of understanding, and 3 being questions that show a high level of understanding). When coupled with the student surveys and interviews, this gave a complete view of the class demeanor before, during, and after the intervention. Table 1 summarizes several techniques that were implemented both quantitatively, through quiz and test scores, and qualitatively, through student surveys, interviews, and instructor observation. In particular, this study looked at whether or not implementing an instructive process on science reading, by teaching students constructive techniques, would improve reading comprehension skills and overall confidence toward those skills as they progressed through the course.

Table 1 *Data Triangulation Matrix*

<b>Focus Questions</b>	<b>Data Source 1</b>	<b>Data Source 2</b>	<b>Data Source 3</b>
<i>Primary Question:</i> <b>1. Will implementing techniques on how to read scientific literature impact student performance in class?</b>	Pre and post test scores	Weekly quizzes on assigned readings	Instructor observations/PLAN diagrams
<i>Secondary Questions:</i> <b>2. Will implementing techniques on how to read scientific literature improve student attitudes in the science classroom?</b>	Student surveys	Student interviews	Weekly quizzes on assigned readings
<b>3. Will implementing techniques on how to read scientific literature improve/increase student participation in the science classroom?</b>	Student surveys	Student interviews	Instructor observations

### DATA AND ANALYSIS

The purpose of this intervention was to see if there is any benefit, both qualitatively and quantitatively, to introducing a reading curriculum into the science classroom. Several methods of data collection were used, including weekly homework quizzes, unit tests, student surveys, student interviews, and teacher observation. The variable group was the 14 student Biochemistry class for a period of 4 weeks, while the control was the same group for the period of 4 weeks preceding the intervention. Also used as a control for comparison was the 2012 Biochemistry course, composed of an almost identical demographic.

### Student Performance in the Science Classroom

Student performance was measured using overall test scores for each unit covered, weekly quizzes on assigned readings, and instructor observation on quality of participation and on the thoroughness of student PLAN diagrams.

Each week, the students were given a homework assignment that involved some level of reading in either a newspaper article, journal article, or medical case study (APPENDIX C). Along with the assignment, the students had to log into the QuizStar program and had one hour to complete a short quiz in reference to that reading. The daily quiz grades on reading assignments for homework showed a very slight increase, as seen in Figure 2.. Inferential statistics were not completed on this date due to the small sample size.. Most students (11/14) in the Post-Intervention Interview said that they felt the quizzes prepared them very well for the unit tests, and the overall test scores did increase by a greater percentage, as seen in Table 2, so that conclusion can be drawn. One student claimed that even though they were not sure if the content on the quizzes helped them in the course, they felt that by taking the weekly quizzes, they “got a feel for the format and style of questions that might be on a future test”. They noted that this made them feel more comfortable going forward in their test preparation. Another student commented on the “instant feedback” that the QuizStar program provided. They stated that the immediate responses from that program allowed them to streamline their studying, and “focus on the areas that were my weak points that night, rather than waiting for them to be graded and given back the next day”.

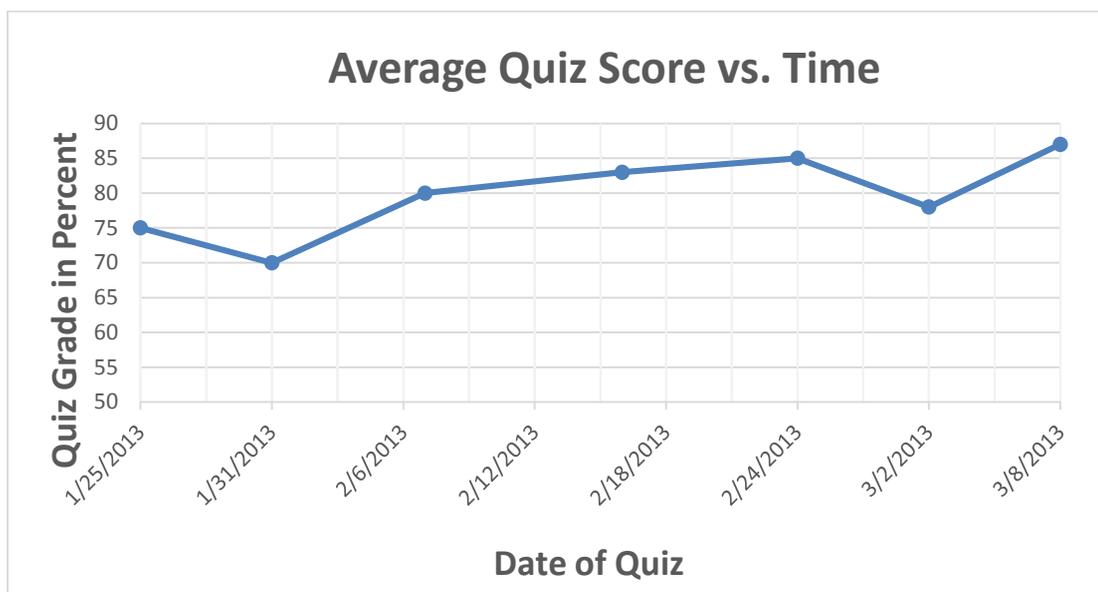


Figure 2. Quiz grades during intervention, ( $n=14$ ).

The unit test scores were compared to those from the Spring 2012 Biochemistry course, as well as from the Spring 2013 class before intervention. Before intervention, which is indicated in the shaded region of Table 2, there was negligible difference in percentage from last year to this year. After intervention, there is a 3-4% increase in grades from year 2012 to year 2013 on exams. That is a fairly substantial increase in a short time, and the overall average from the 2013 group specifically increased as well, indicating that something certainly caused an improvement in their grades. Again, the sample size here is too small to say for certain that this is a statistically significant increase, but it is a noticeable increase. This, coupled with the interview and survey questions in which students indicated that they felt like they had improved, is a solid indication that the implementation of the PLAN technique had some positive effect on the overall student body in the class.

Table 2  
*Test Grade Comparisons from 2012 to 2013 (n=14)*

<b>Unit</b>	<b>Average 2012</b>	<b>Average 2013</b>	
<b>Digestion (2 weeks)</b>	85.70%	85.50%	Pre-Intervention
<b>Vitamins (2 weeks)</b>	82.10%	83.40%	
<b>Minerals (1 week)</b>	79.30%	84.20%	Intervention
<b>Drug Metabolism (1 week)</b>	84.50%	87%	
<b>Immunology (2 weeks)</b>	84.35%	88.20%	
<b>Post-Intervention Mean</b>	82.70%	86.46%	

The final method of data collection for this question, was the actual student PLAN diagrams. While some students were resistant to the process early on, most were on board with the technique by the conclusion of the intervention. The diagrams got more involved and detailed in each unit, but more importantly, the students began to add in very insightful details that showed a higher level of understanding. As shown in Figures 3 and 4 below, one particular student demonstrated this from Unit 1 (digestive system) to Unit 3 (immune system). In the first diagram (Figure 3), it was simply an organization of the reading with a few definitions. In the second diagram (Figure 4), the student not only included key definitions, but also how each part related to the others, drawing connecting arrows between the boxes. Also, they added several details that demonstrated true understanding and ability to relate to real-world applications, such as the comment next to antigen, where it says “why people with bad diet get sick”, or under the description of a macrophage, they said “like Pac-man”. These comments are certainly evidence of progress in both comprehension of the material, and effort on the assignment and

demonstrate some of the strongest evidence that progress was made throughout the intervention process, as these examples were from the same student.

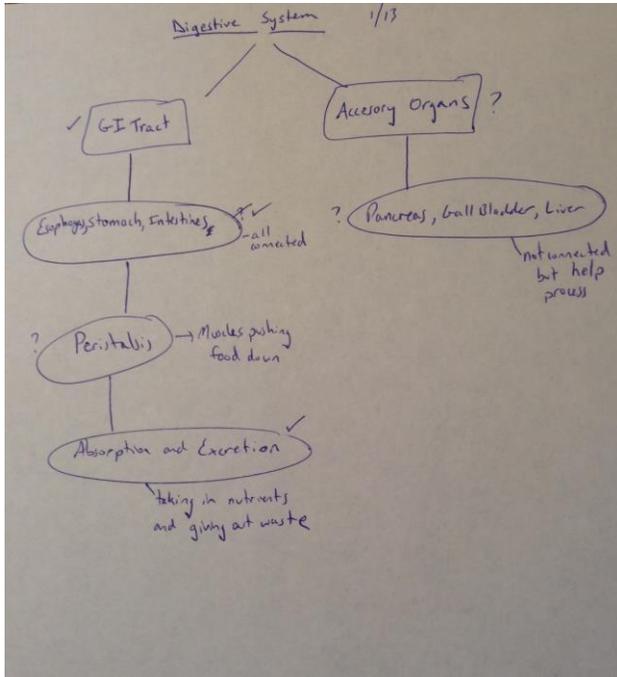


Figure 3. Sample PLAN diagram from “Student A”, showing detail from Unit 1: Digestive System.

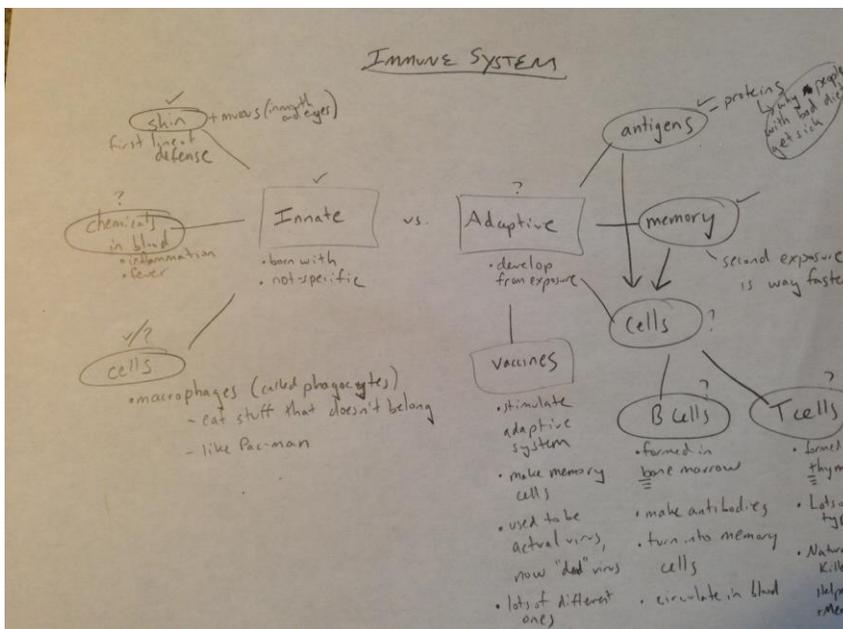


Figure 4. Sample PLAN diagram from “Student A”, showing detail from Unit 3: Immune System.

Effect on Student Attitude in the Classroom

The effect on the overall attitude of the students in the classroom was measured primarily by student interviews and surveys. The overall quiz grades were also used as a secondary measurement, to help determine the relationship between attitude and a grade. Clearly, as evidenced by Table 3, the students in the Biochemistry course felt that they could benefit from some formal training in how to read scientific literature effectively, as all 14 students agreed or strongly agreed on the Initial Student Survey. What was interesting was that several of them felt like they had been previously instructed on how to read effectively, despite their lack of confidence in that area.

Table 3  
*Initial Student Survey (n= 14)*

<b>Question</b>	<b>Strongly Agree</b>	<b>Agree</b>	<b>Not Sure</b>	<b>Disagree</b>	<b>Strongly Disagree</b>
1. I have been previously instructed on how to read scientific literature (i.e. textbooks and journal articles).	0	4	3	5	2
2. I feel confident in my ability to read scientific literature.	0	3	4	5	2
3. I think I could benefit from more instruction on reading scientific literature effectively.	8	6	0	0	0
4. In my previous science classes, reading and understanding a textbook was an expected obligation.	1	6	3	3	1
5. Reading science textbooks helps me to understand the material covered in class.	2	8	2	1	1

6. I am planning on taking science courses in college.	8	4	0	1	1
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These data were supported by the Pre-Intervention Interview Questions (APPENDIX E), where the students expressed both an interest in pursuing science at the collegiate level, and a general belief that they had been previously instructed in how to read science literature. One student responded that she had been heavily instructed in the “Cornell Note-taking System”, which demonstrates how to record, reflect, and review information from lectures and readings. However, when I questioned the student further on what she felt the purpose of such instruction was, she replied with “I have no idea, it was homework, so I did it”. Whether that previous instruction was beneficial or not was difficult to measure, because many of the students did not fully embrace those teachings, but rather went through the motions and completed assignments, rather than learning a technique that could further improve their ability. Figure 5 does show a noticeable increase in student perception of how well the intervention worked, with survey question number 1 compared both before and after intervention. It is clearly shown that the students felt that this process was beneficial.

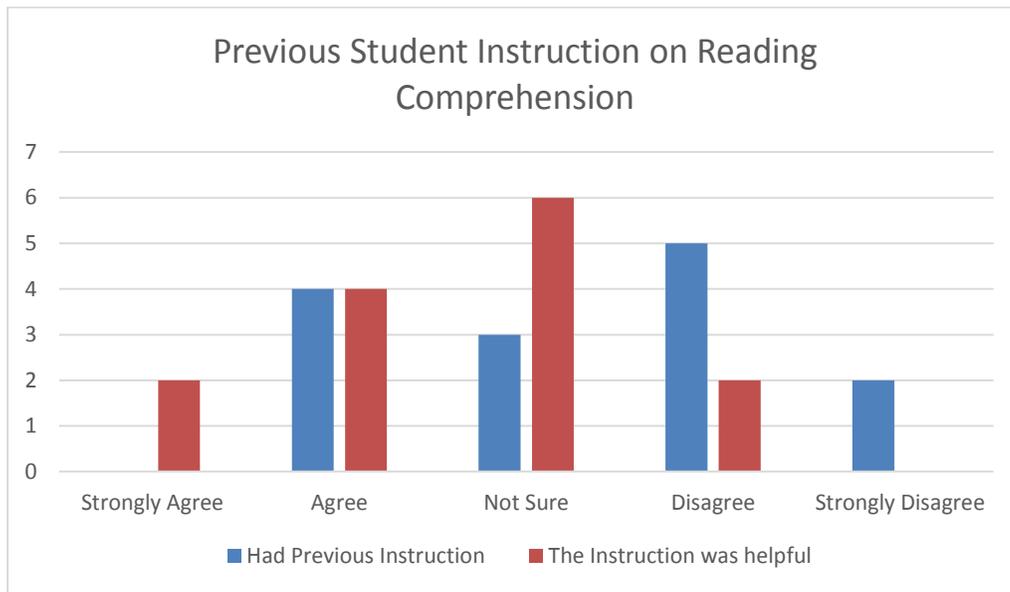


Figure 5. *Student Survey Question 1, previous instruction on scientific reading techniques, (n=14).*

This was something that was difficult to measure, but the classroom participation aspect of this study did address it. Also in the interview questions, over half of the students claimed that reading a text was an expected obligation in the course, and that reading textbooks greatly benefits them in understanding science material. This was a bit surprising given their initial answers that they are not overly confident in that ability.

The student interviews provided some clarity with these results. Of the 14 students in the class, 5 students were purposefully selected to represent the diversity of the class. 3 females and 2 males were asked the questions and some of their quotes are given below. The interview questions gave a little more insight into the attitudes of the students, because out of the 5 students that were selected to be interviewed, the average response was that they felt an average of an 8 on a scale of 1-10 in their level of improvement and ability to understand the course material and 4 out of the 5 responded that they felt better about the course after the intervention, with the one other student

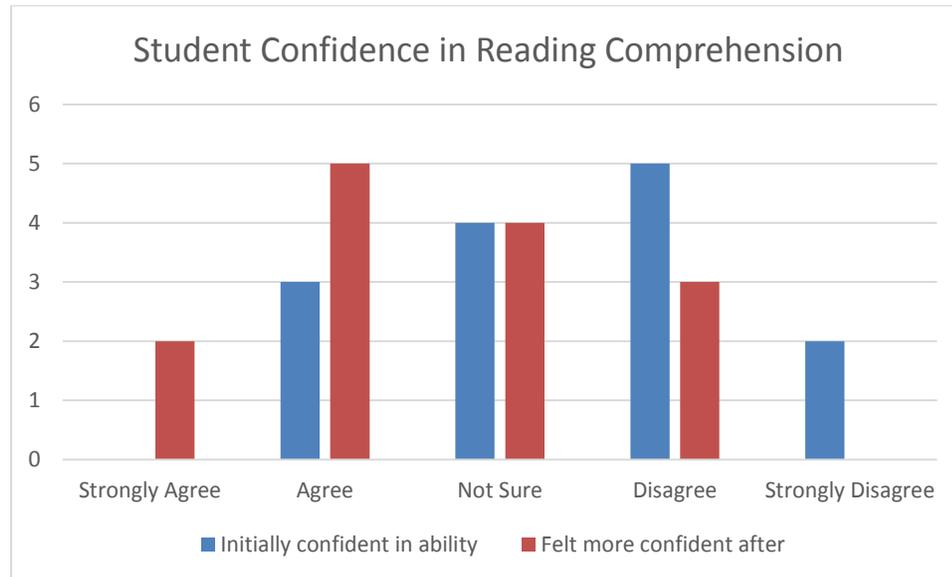
replying with “no change”. In all, though not all students showed a benefit in grade, participation, or perception, the slight majority did, and none of the students felt that it was a detriment in any way.

Table 4  
*Final Student Survey (n=14)*

<b>Question</b>	<b>Strongly Agree</b>	<b>Agree</b>	<b>Not Sure</b>	<b>Disagree</b>	<b>Strongly Disagree</b>
1. The recent instruction on the process of scientific reading was helpful in my understanding of scientific literature.	2	4	6	2	0
2. I feel more confident in my ability to read scientific literature after using the PLAN technique.	2	5	4	2	0
3. My performance on assessments has improved as a result of the PLAN technique.	1	4	4	3	1
4. My class participation improved after using the PLAN technique.	3	4	6	1	0
5. The PLAN technique is something I will apply to future courses (science or otherwise).	0	3	8	3	0
6. The QuizStar quizzes were helpful in preparing me for in class assessments.	6	4	3	1	0
7. My performance on assessments improved as a result of the QuizStar quizzes.	2	5	6	1	0

To better see the comparison between the before and after of the students, figures 4 and 5 show the results of survey questions 1 and 2 respectively. These figures show that there was a general trend of the students over time to agree that the results of the intervention

were positive. Most noticeable, in figure 6, the two students who initially strongly disagreed that they had confidence in scientific reading comprehension changed their opinion quite drastically.



*Figure 6.* Student Survey Question 2, confidence before and after intervention, ( $n = 14$ ).

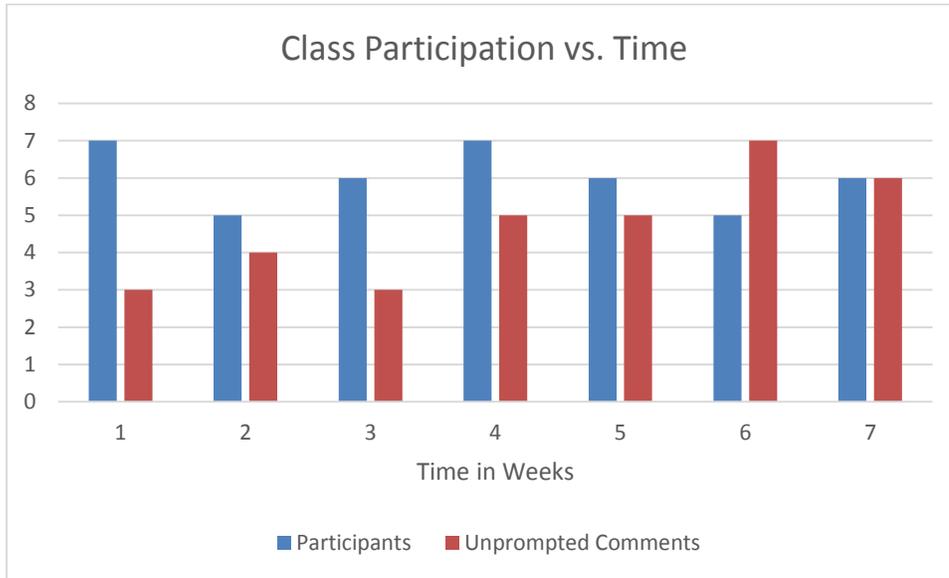
### Effect on Class Participation

The classroom participation was assessed both on quantity and quality of the student engagement in class, followed by the student interview responses about their personal feeling about their confidence in participating.

Students participated actively in class better as the intervention time went on, as seen in Figure 7. In each class, the average number of unprompted questions from students increased slightly over time, with a 2.5 question per class increase. Though the actual number of students participating did not noticeably change, the quality and spontaneity did. This is a sign that the students felt more confident in their ability to comprehend the readings and lectures, and was solidified during the Post-Intervention

Interview Questions, where 90% of the students asked, replied that their overall confidence in reading and comprehending had increased during the intervention. Though the sheer number of students participating did not increase by any measureable number, the quality of participation was greater. For example, rather than a student asking for a simple definition, the student was asking how this unit related to a previous unit, showing a higher level of comprehension that is difficult to measure quantitatively. These data are quite anecdotal from the perspective of the instructor, and was not documented specifically.

Results from the post-intervention surveys (Table 4) showed that the students felt better about their understanding and performance. Though this question may have been skewed because the students did not know that their participation was being tracked, the fact that their perception of participation was more positive after intervention is important to note. Questions 3, 4, and 5 show a varied response with many students electing to choose the “not sure” option on the survey. It was interesting to see the student response to number 4, in particular, because the students did not seem to be aware of their level of participation compared to previous units. This is perhaps a fault of the data collection methods, as it was very informal and the students did not receive specific feedback regarding number of times they raised their hands, etc. before, during, or after the intervention, so they had no real basis for comparison. Overall, the sheer increase in the “unprompted questions” is the most compelling evidence that the PLAN technique did, in fact, have an impact on the students’ participation in the Biochemistry course.



*Figure 7.* Class Participation Progress. One class session each week was sampled, ( $n=14$ ).

#### INTERPRETATION AND CONCLUSION

The PLAN technique can be easily implemented into most classrooms with little effort from student or instructor. Though time must be allotted in class to allow students to work at their own pace and truly develop ideas about what they have read, it has provided some great benefits to them in the long-term, such as more thoughtful and in-depth comments in class, and more retention for chapter tests. The once-a-week method worked well, in that it did not disrupt the flow of the class very much and the normal lecture process and it also gave a sort of rhythm that the students seemed to enjoy. Their diagrams got more in depth and showed a higher level of thinking as time progressed, so the implementation was effective in that way. While this is not the only way to interject reading comprehension, it was effective, and more effective than any other methods that I had previously tried over the years in my teaching. The greatest benefit from the intervention seemed to be the QuizStar quizzes. Though student grades on the quizzes themselves did not increase very much over time, their Unit Test grades increased

slightly in accordance with the quiz grades, indicating that seeing and working through similar questions before a test was beneficial, even if they got the initial attempt wrong. It also increased their confidence in class because the quizzes gave instant feedback the evening before, so they felt better prepared to respond to questions in class in the following days. Again, the limitation here was time, and creating the quizzes more than once a week was not sustainable for the instructor, given the demands of the boarding school environment. It did seem that the cost of class time in lectures did not hinder the progression of the students, but rather the integration of reading techniques improved it. Overall, though the results were not staggering, there was no negative impact on the course, the students, or the instructor, so any benefit would be worth the loss of lecture time. Results also matched the previous research in this field, with overall test scores not necessarily improving, but rather the students providing a higher order of thinking and quality of class participation and responses to questions (Radcliff, Caverly, Peterson, and Emmons, 2004).

#### VALUE

The results of this study indicated that students benefited from being shown techniques in reading science literature. Though this was done in just one course, the impact would seem to be much greater if it were implemented into the curriculum in each course, at every grade level. Given the small amount of success seen at the junior and senior level in this study, I believe that the PLAN technique would best be served to be integrated into the 9<sup>th</sup> grade level science, allowing students to benefit from that knowledge in future science courses. With the increases in technology in recent years and more schools moving to online learning, students will need to rely on their own

ability to read, comprehend, and reproduce material almost entirely on their own, moving away from the classic lecture-style classroom that many have been accustomed to for so long.

Though the PLAN Technique worked well in this scenario, particularly with a small group, there are several other similar options available that instructors could easily implement on a regular basis in the classroom with minimal impact on the day to day classroom experience. Gaining the ability to speak in front of peers with a level of confidence about a subject is also an incredibly important skill that often gets lost in the science classroom and emphasized in the humanities. With so much of studying science being the ability to share and collaborate ideas, it is becoming more and more vital that aspiring scientists be able to articulate their thoughts and present their findings in a clear and decisive way, while also being able to read and evaluate works from their peers. Both of these concepts were achieved using the PLAN Technique in 12<sup>th</sup> grade Biochemistry, and with a similar implementation method, I believe the majority of high school science students would benefit from mastering those skills at the Secondary level in order to best prepare them for the next level of education.

This project both confirmed my initial hypothesis, that students can benefit from an alternative way of teaching reading comprehension, focused on scientific applications, but also that the numerical outcome is not always the desired one. It would have been wonderful to see the test scores increase dramatically, but the more intangible results are what impacted me most as an instructor. The confidence and participation made the classroom environment more dynamic and engaging for both students and instructor, and the excitement generated from that confidence re-invigorated my own energy for

teaching. Moving forward, I aim to continue to implement the PLAN technique for my students, while also sharing these results with colleagues. Ideally, we will begin to implement this at the 9<sup>th</sup> grade level, then track the progress of our students over a four year period of time, which would provide even more clarity on the results of this study, but also a more comprehensive compilation of data, as the disciplines are vastly different each year (biology, chemistry, physics, electives, APs, etc.). Also, I plan to include periodic student presentations on material, such as laboratory results or the case studies used in this experiment. With public speaking being a huge initiative currently at our school, this fits in well with that appeal, while also building on the findings here, that with proper technique and practice, students will have the confidence to participate at a level of high quality. The skill of being able to articulate and explain scientific data to peers is an invaluable one in the science classroom at any level, and implementing a curriculum to help students feel better about that process would certainly be an asset to them moving forward in their education. This study has affected my teaching greatly, and helped me narrow my focus to a few target areas that I feel will most impact my daily teaching. Giving my students smaller, more manageable daily assignments, creating a classroom forum to discuss their ideas, and providing them with a framework for understanding scientific reading (the PLAN technique), will be the basis of my teaching in the coming years, and I am grateful to this process for continuing to shape me as an educator. Lastly, since this research, I have moved on to using an alternative to the classic science textbook in all of my classes (with the one exception being my AP course). There is a wonderful new website through the CK-12 Foundation, called “Flexbook”, which enables you to choose a book that they already have available online,

and edit, rearrange, and customize to your particular course. This has seemed to work for me as the best of both worlds. I am not requiring the purchase of an expensive textbook that my students will rarely use, but rather using a free resource that allows me to only put in content that makes sense for my course. This has been a wonderful tool moving forward, and one I would likely not have encountered without going through the process of this research. Overall, while I still have some unanswered questions, the feedback I did receive has proved invaluable, and I am looking forward to implementing these tactics in the immediate future.

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APPENDICES

APPENDIX A  
INITIAL STUDENT SURVEY

<b>Question</b>	<b>Strongly Agree</b>	<b>Agree</b>	<b>Not Sure</b>	<b>Disagree</b>	<b>Strongly Disagree</b>
1. I have been previously instructed on how to read scientific literature (i.e. textbooks and journal articles).					
2. I feel confident in my ability to read scientific literature.					
3. I think I could benefit from more instruction on reading scientific literature effectively.					
4. In my previous science classes, reading and understanding a textbook was an expected obligation.					
5. Reading science textbooks helps me to understand the material covered in class.					
6. I am planning on taking science courses in college.					

APPENDIX B  
FINAL STUDENT SURVEY

Question	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. The recent instruction on the process of scientific reading was helpful in my understanding of scientific literature.					
2. I feel more confident in my ability to read scientific literature after using the PLAN technique.					
3. My performance on assessments has improved as a result of the PLAN technique.					
4. My class participation improved after using the PLAN technique.					
5. The PLAN technique is something I will apply to future courses (science or otherwise).					
6. The QuizStar quizzes were helpful in preparing me for in class assessments.					
7. My performance on assessments improved as a result of the QuizStar quizzes.					

APPENDIX C

CASE STUDY: ACID REFLUX

**Case Study 8.1: Acid Reflux**

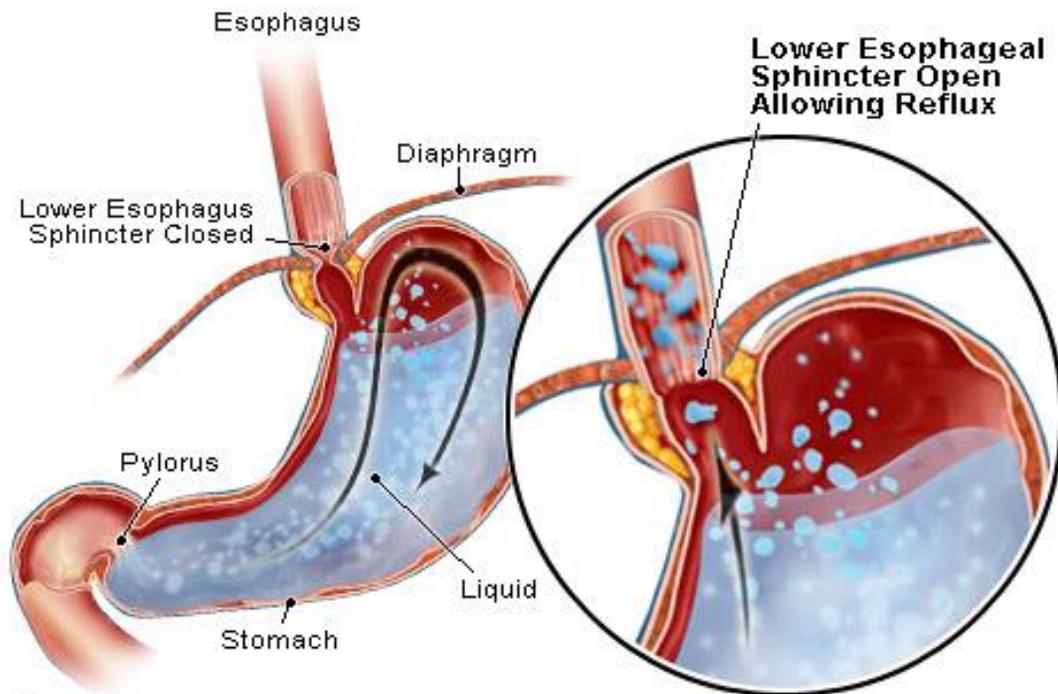
Name: \_\_\_\_\_

**Background...**

Acid reflux disorder, also known as gastroesophageal reflux disease (GERD) is a condition in which the liquid content of the stomach regurgitates into the esophagus. The liquid can inflame and damage the lining of the esophagus and cause esophagitis. It usually contains acid and pepsin, both released by the stomach, and may also contain a small amount of bile. Acid is believed to be the most injurious component of the refluxed liquid. Pepsin and bile also may injure the esophagus, but their role in the production of esophageal inflammation and damage is not as clear as the role of acid.

GERD is a chronic condition. Once it begins, it usually is life-long. If there is injury to the lining of the esophagus (esophagitis), this also is a chronic condition. Moreover, after the esophagus has healed with treatment and treatment is stopped, the injury will return in most patients within a few months. Once treatment for GERD is begun, therefore, it usually will need to be continued indefinitely.

As is often the case, the body has ways (mechanisms) to protect itself from the harmful effects of reflux and acid. For example, most reflux occurs during the day when individuals are upright. In the upright position, the refluxed liquid is more likely to flow back down into the stomach due to the effect of gravity. In addition, while individuals are awake, they repeatedly swallow, whether or not there is reflux. Each swallow carries any refluxed liquid back into the stomach. Finally, the salivary glands in the mouth produce saliva, which contains bicarbonate. With each swallow, bicarbonate-containing saliva travels down the esophagus. The bicarbonate neutralizes the small amount of acid that remains in the esophagus after gravity and swallowing have removed most of the liquid. Gravity, swallowing, and saliva are important protective mechanisms for the esophagus, but they are effective only when individuals are in the upright position. At night during [sleep](#), gravity is not in effect, swallowing stops, and the secretion of saliva is reduced. Therefore, reflux that occurs at night is more likely to result in acid remaining in the esophagus longer and causing greater damage to the esophagus.



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## Gastroesophageal Reflux

### Questions...

1. Certain conditions, such as pregnancy, can make a person more susceptible to GERD. Explain why this may happen. (HINT: Think about our last unit)
2. Explain why people with diseases that weaken muscles may also experience this.
3. What would some treatments be for GERD and why would they work?
4. What effect would the enzyme pepsin have when it is pushed up into the esophagus in this condition?

APPENDIX D

YOUR DIGESTIVE SYSTEM AND HOW IT WORKS

## National Digestive Diseases Information Clearinghouse

U.S. Department of Health and Human Services

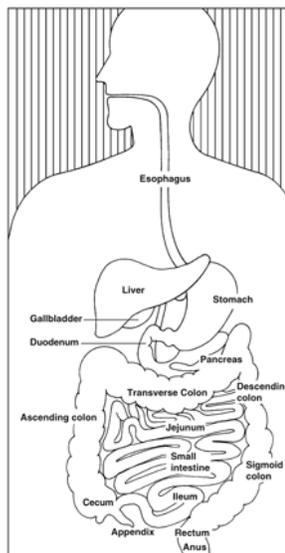
### NATIONAL INSTITUTES OF HEALTH

The digestive system is made up of the digestive tract—a series of hollow organs joined in a long, twisting tube from the mouth to the anus—and other organs that help the body

break down and absorb food (see figure). **Pancreas Liver Gallbladder Duodenum**

**Stomach Transverse Colon Descending colon Ascending colon Cecum Appendix**

**Rectum Small intestine Sigmoid colon Anus Ileum Jejunum Esophagus**



Organs that make up the digestive tract are the mouth, esophagus, stomach, small intestine, large intestine—also called the colon—rectum, and anus. Inside these hollow organs is a lining called the mucosa. In the mouth, stomach, and small intestine, the

mucosa contains tiny glands that produce juices to help digest food. The digestive tract also contains a layer of smooth muscle that helps break down food and move it along the tract.

Two “solid” digestive organs, the liver and the pancreas, produce digestive juices that reach the intestine through small tubes called ducts. The gallbladder stores the liver’s digestive juices until they are needed in the intestine. Parts of the nervous and circulatory systems also play major roles in the digestive system.

### **Why is digestion important?**

When you eat foods—such as bread, meat, and vegetables—they are not in a form that the body can use as nourishment. Food and drink must be changed into smaller molecules of nutrients before they can be absorbed into the blood and carried to cells throughout the body. Digestion is the process by which food and drink are broken down into their smallest parts so the body can use them to build and nourish cells and to provide energy.

### **Questions asked via online program QuizStar**

1. All of the following are part of the digestive tract, except:
  - a. Mouth
  - b. Pancreas
  - c. Small Intestine
  - d. Colon
2. The common name for the large intestine is:
  - a. Bile
  - b. Gall Bladder
  - c. Colon
  - d. Pancreas
3. What type of muscle is used in the digestive tract to propel food?
  - a. Smooth

- b. Striated
  - c. Cardiac
  - d. Voluntary
4. This organ stores the liver's juices until they are needed in the intestines.
- a. Pancreas
  - b. Gall Bladder
  - c. Small intestine
  - d. Mouth
5. When you eat foods, they are in a form that the body can readily digest.
- a. True
  - b. False
6. Carbohydrates are broken down into \_\_\_\_\_ to be absorbed:
- a. Amino acids
  - b. Triglycerides
  - c. Monosaccharides
  - d. Steroids
7. Proteins are broken down into \_\_\_\_\_ to be absorbed:
- a. Amino acids
  - b. Triglycerides
  - c. Monosaccharides
  - d. Steroids
8. The digestive system and circulatory systems are connected so that material can flow freely between the two systems.
- a. True
  - b. False

APPENDIX E  
STUDENT INITIAL INTERVIEW

1. What previous science courses have you taken at the high school level?
2. Have you even been given any instruction on reading comprehension? If so, when?
3. Have you ever been given any instruction on how to read science text, in particular?
4. On a scale of 1-10, with 10 being the most confident, how confident are you in your ability to read, comprehend, and digest material in this class?
5. What science courses, if any, are you planning on taking in the future (both in high school and college)?
6. Do you feel that you understand the content being asked on quizzes and tests in this course?

APPENDIX F  
FINAL STUDENT SURVEY

1. Did you feel that the in-class instruction and PLAN diagrams were helpful in understanding the readings?
2. On a scale of 1-10, with 10 being the most confident, how confident are you in your ability to read, comprehend, and digest material in this class?
3. Do you feel that you understand the content being asked on quizzes and tests in this course (better, worse, or no change from before)?
4. Has this process altered your opinion on scientific reading? Yes or no?
5. Were there any specific parts to reading instruction that stick out in your memory as being helpful?
6. Were there any specific parts to reading instruction that stick out in your memory as being detrimental?