

THE EFFECT OF TRAINING IN QUESTION GENERATION ON THE
DEVELOPMENT OF BETTER QUESTIONS POSED BY
SEVENTH GRADE SCIENCE STUDENTS

by

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DEDICATION

The research communicated in this paper, as well as all the work that went in to pursuing the degree of Master of Science in Science Education, is dedicated first to my parents, who have always provided me with an inordinate amount of love, support, and understanding, but even more so throughout this educational experience.

This work is also dedicated to my students at Hackensack Middle School - past, present, and future. This would not have been possible without you, as you make me want to be the best for you.

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ABSTRACT

Student generation of good questions provides many benefits for students, including active engagement in learning and development of their curiosity, as well as benefitting the teacher by providing him or her with insight as to the level of comprehension of the student, or enabling the class to dive deeper into content. But how can students develop good questioning skills? This study sought to explore how to develop good questioning skills in my middle school students by implementing the Question Formulation Technique (QFT), and examining how this training affected their ability to comprehend readings and answer open-ended questions. Two groups of students were included in the study, with one group participating in the QFT process throughout one unit of study, and the other group proceeding with traditional teacher-developed questions. Through comparisons between pre- and post-assessments, interviews, observations, surveys, and written assignments, instruction on question generation was found to improve the quality of students' questions, as well as improve their confidence in asking questions.

INTRODUCTION AND BACKGROUND

The 2016-17 academic year will mark my 13th year teaching seventh grade science at Hackensack Middle School (HMS). Though the curriculum during my tenure at HMS has focused solely on life science, the 2016-17 school year will feature a move to the recommended spiral curriculum model, as designed by the New Jersey Department of Education, and the implementation of the Next Generation Science Standards.

My students generally enjoy science. They love the days in which a hands-on lesson is presented to them, and complete their work on days when study skills and strategies are reinforced. Some of my students love the subject and hope to pursue careers in the sciences, while others are interested in the content but love other fields of study. Due to the nature of my subject matter, I have found that students who are good at memorizing and enter my classroom with proficient study skills perform better on assessments than students for whom studying is a work in progress. However, I have found that even those students who are successful in my class are weak when it comes to taking ownership of their learning and experiencing the thrill of discovery. They do not ask good, relevant questions and then pursue answers to those questions because they do not know how to, often preferring for the information to be provided to them.

School Demographics

The city of Hackensack sits approximately eight miles from the New York side of the George Washington Bridge, in Bergen County, New Jersey. It is the county seat, and features a population of approximately 44,519 residents (United States Census Bureau, n.d.). According to data collected in 2014, HMS had a total enrollment of 1,392 students

in grades 5 through 8. Latinos comprise the greatest portion of HMS's student body, making up 58.48% of the school population. African Americans comprise the second largest ethnic group at 29.09%, followed by Caucasian students at 6.18%, Asian students at 6.03%, and American Indian/Alaskan, Pacific Islander, and multi-racial students each accounting for 0.07% of the school population (Hackensack Middle School, n.d.). Most of the Latino students at HMS are bilingual, and many have parents who speak little to no English at all. Due to the various ethnic backgrounds of our students, the culture of HMS is one that focuses on highlighting and appreciating our diversity.

Focus Question

In my project, I sought to explore how to develop good questioning skills in my students. This research topic led me to focus on several possible research questions, including: Will training in question generation lead to the development of better questions posed by students? An additional question included in my focus was: will the generation of good questions improve students' ability to comprehend readings? The last question that was explored through research is: will training in question generation improve students' ability to answer open-ended response assessment questions?

CONCEPTUAL FRAMEWORK

For the purpose of discussion, the literature reviewed will be organized into three main parts. The first part of the conceptual framework will discuss the rationale for student questioning, presenting reasoning as to why the skill should be incorporated into the science classroom. The second part will identify the criteria for good student

questioning. Finally, the remainder of the framework will discuss strategies employed in other studies that target student questioning.

Rationale for Student Questioning

Traditionally, students in classrooms of nearly every discipline approach the content through the pursuit of answers to questions posed by the instructor or the curriculum's materials. The instructor may assign a reading passage with prepared comprehension questions in accompaniment, or he or she may engage the class in an oral session of questioning in review of content learned or read. Such methods do check for understanding of content attainment, but resides very low in Bloom's taxonomy of cognitive development (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956). Answering questions formulated by the instructor demonstrates recall and understanding, but doesn't necessarily aid in long-term learning. The student generation of higher order questions may lead to long-term learning and higher cognitive development (Cuccio-Schirripa & Steiner, 2000).

Student generation of questions provides several benefits to both student and teachers. First, the data collected from several studies suggests that students may become more actively engaged in reading comprehension when they effectively generate their own questions (Davey & McBride, 1986). The act of students generating their own questions alone creates a focus on the content at hand, identifying main ideas and supporting details, while initiating a pursuit into further research (Rosenshine, Meister & Chapman, 1996). Development of their own questions provides the student with a means by which to assess themselves, checking their own level of understanding (Chin &

Brown, 2016). The feedback that is generated may prompt the learner to delve deeper into his or her own understandings, as well as misunderstandings, and provide the platform by which they may craft their own learning pathway.

Second, question generation not only aids in the learning of the student, but also provides valuable feedback to the instructor in regard to the level of comprehension and quality of thinking on behalf of the student (Chin & Brown, 2002). Such valuable insight may indicate to an instructor whether it is time to move on, or spend more time, in a lesson of study. Additionally, student-generated questions may make light of misconceptions harbored by the learners, enabling the instructor to address them as necessary.

Lastly, directing students to generate their own questions can help the instructor to dive deeper into areas of text or content that would never have occurred to them without the feedback. Students enter the classroom environment with a wide diversity of personal experiences and educational understandings. Some students are eager to pursue science outside of the educational demands, watching nature documentaries and science programming during their free time, while other students may not have that personal vestment in the sciences, in or outside of the classroom. Either way, our students provide us with perspectives completely different than our own, raising questions that may never have occurred to the instructor. The questions generated by students may provide the instructor with a platform from which rich learning opportunities can be developed (Commeyras, 1995).

Criteria for Good Student Questioning

The focus of this study is the development of good questioning skills, but what qualifies a student-generated question as “good”? The desired question should be one that is researchable, posing questions that may lead the student into further investigation. These questions may be developed through observation of demonstrated phenomena, hands-on experience, or by reading content in various forms of print (Cuccio-Schirripa & Steiner, 2000). Researchable questions can, additionally, be defined as questioning that has the potential to induce learning (Cuccio-Schirripa & Steiner, 2000). Such questions lead the student to build connections between their prior knowledge and new information presented in one of the aforementioned experiences, often leading to further meaningful, or “good”, questions. The development and pursuit of these self-generated questions has been shown lead to deeper understanding and greater information retention than with instructor-posed questions alone (Olsher & Dreyfus, 1999).

Strategies That Target Student Questioning

Though some students may have an innate sense of curiosity, most will have to learn how to develop meaningful questions that are intended to enrich learning (MacKenzie, 2001). Davey and McBride (1986) found positive results in their question generation training study. Though several strategies were used for comparison, students in one of the experimental groups received directed instruction over a two-week period in question-generation from instructors who had been trained in selected procedures. The instructors directed the students to formulate questions that linked information across sentences and questions that identified the most important information. The students’

training not only focused on working with the selected text, but also included instruction on the use of Likert-type monitoring checklists, including questions such as: “how well did I identify important information?”, “how well did I link information together?”, and “how well could I answer my question?”. Additionally, the students’ training helped them to indicate the appropriate time to apply question generation. The positive outcomes noted included improvements on the generated questions themselves and improved student responses to comprehension questions.

In addition to providing instruction on how to generate meaningful questions, Hofstein, Navon, Kipnis and Mamlok-Naaman (2005) stress the importance of the environment in student-generated questions. They suggest that opportunities must be crafted in the classroom to encourage curiosity and deviate from a strictly factual-type line of questioning. These opportunities may include participation in inquiry activities, or by connecting what may be perceived as an arbitrary scientific process to the everyday lives of the students studying them. Making personal connections with these unseen scientific processes can help the student to develop the meaningful questions that will enhance learning (Olsher & Dreyfus, 1999).

Finally, MacKenzie (2010) focused on the role of the instructor when facilitating the development of questioning skills among students. The stance that the instructor takes in the classroom drives the level of engagement and sense of wonder exhibited by the students. An instructor, who visibly dedicates him or herself to inquiry, encouraging scientific interaction amongst his or her students, will naturally aid in the development of such qualities in the students. Whether an inquiry activity takes the form of a discussion,

debate or a project, it is the instructor's influence that instills the sense of wonder and curiosity that drives the development of meaningful student-generated questions (MacKenzie, 2010).

Through the research conducted, it is apparent that there is not one single factor that can lead to the development of good questioning skills among learners. Direct instruction in question generation has been found to have the greatest influence on improving the cognitive level of the students involved, whereas the environment and activities involved spark the questioning process. Taking all the information into account, learners need to be a part of experiences that drive them to develop questions that will enhance learning, but require the instruction necessary to ensure that the questions developed are truly meaningful.

The most interesting methodological approach that I reviewed throughout my research was that of the approach taken by Davey and McBride (1986). I appreciate the setup of the experimental groups, as one of the experimental groups received directed question generation training, three others received various questioning practice, and a fifth group received no training or practice at all. This design addresses the effectiveness of training in the development of meaningful questions in science.

The study conducted by Davey and McBride (1986), however, dealt solely with the development of good questions from reading passages. In an effort to provide students with valuable opportunities to ask meaningful questions, Hofstein, et al. (2004), stressed the importance of laboratory experiences and phenomena-demonstrating activities. Deriving meaningful questions from text is a skill of great importance,

providing valuable information in regard the level of understanding and focus on the part of the learner (Chin & Brown, 2002), but may not instill a sense of wonder that may lead to further learning.

METHODOLOGY

The intent of this classroom research-based project is to develop good questioning skills in my students. In order to do this, I investigated how effective training in question generation will be in leading to the development of better questions posed by students. Additionally, I was able to determine if the generation of good questions will lead to the improvement of student ability to comprehend assigned readings. Finally, I explored the effect of training in question generation on student ability to answer open-ended response assessment questions.

Participants

The participants for my study included the 79 students enrolled in my four seventh grade classes. Periods two and three received the treatment. The treatment group consisted of 34 students: 16 boys and 18 girls. Of the students that received the treatment, 54% are identified by the Hackensack Public Schools as having a home language other than English (i.e. Spanish, Bengali, Punjabi, or Uzbek). Periods four and six served as the comparison in this study, and consisted of 45 students: 22 boys and 23 girls. Students with home languages other than English comprised 38% of the comparison group.

Intervention

For this classroom research-based project, I used Rothstein and Santana's (2011) process for question generation, called the Question Formulation Technique (QFT), with

my seventh grade science students. The QFT assists students in generating their own questions, refining them, and identifying how to use them to their advantage.

The QFT involves six key steps, beginning with the teacher presenting a focus to attract student attention and stimulate the formation of questions. The second step follows with the students producing their own questions using four rules. The rules include: ask as many questions as you can; do not stop to discuss, judge or answer the questions; write down every question exactly as it is stated; and change any statement into a question. The third step involves student improvement of questions by categorization as closed or open-ended, identifying advantages and disadvantages of each type of question, and changing questions from one type to another. Step four features a prioritization of the questions, selecting the most important questions and providing a rationale for the selection. In step five, the students and teacher identify how they will use their questions, and step six features student reflection on what they have learned through the process.

As my schedule is designed, I teach four parallel sections of seventh grade science, with each section covering the same content on any selected day. I applied the intervention to two of the four sections, while instructing the remaining two sections without any intervention, serving as the comparison group. The comparison group did not receive any instruction in QFT, and received content instruction in the same manner that I have always taught (i.e. with a focus on instructor-developed questions). Both the intervention and comparison groups participated in pre- and post-tests, used to determine the effectiveness of the strategy.

The intervention closely adhered to the steps of Rothstein and Santana's (2011) QFT process, beginning with the formulation of a Question Focus (QFocus) by the instructor. A new QFocus was introduced every other Monday by the instructor, with the topic coinciding directly with the content covered that week. The instructor then introduced the rules for producing questions, addressing any concerns or misconceptions regarding their implementation. The students were then broken into groups of three or four, and were instructed to produce as many questions as they could, stemming from the QFocus. Once their list of questions was created by each group, the students then identified the questions as being closed-ended or open-ended. They then began to prioritize the questions, selecting three questions from their generated list that they would like to address or explore first. Each member of the group then selected one priority question to research, compile into a presentation, and present to the class.

At the core of my intervention, I drew the focus of my students and stimulated the question-generation process through the use of a demonstration, one in which an indicator was used to determine the presence of carbon dioxide in my contained breath. Normally, as was experienced with the comparison group, teacher-created questions sheets would be completed during the observation activity. During the intervention, however, the students receiving the treatment were instructed to follow the QFT process, designing and discussing their own questions about the event that they had witnessed.

Another application of the intervention featured written prompts designed to stimulate student questioning. In an effort to develop a connection between the different body systems within the human body, the prompt, *Complications from diabetes can lead*

to heart disease, nerve damage, kidney damage, eye damage, foot damage, skin conditions, hearing impairment, and Alzheimer's disease, was presented as a focus.

Students in the treatment group made their way through the QFT process, questioning how diabetes can cause an array of complications throughout the body. Students in the comparison group read an article on diabetes and answered teacher-created questions about the disease.

Data Collection

Table 1's triangulation matrix visually represents the various forms of data that was collected through my classroom research, indicating which questions the data supports. This project was reviewed and approved by Montana State University's Institutional Review Board (Appendix A).

Table 1
Triangulation Matrix

Focus Question	Data Source 1	Data Source 2	Data Source 3
Will training in question generation lead to the development of better questions posed by students?	Observational data	Student interviews	Student surveys
Will the generation of good questions improve students' ability to comprehend readings?	Pre- and post-assessment	Article summaries	Student surveys
Will training in question generation improve students' ability to answer open-ended response assessment questions?	Pre- and post-assessment	Written assignments	Attitude scales

To address the primary question, Will training in question generation lead to the development of better questions posed by students?, anecdotal and observational data was collected. Groups were monitored by the instructor and field notes were recorded as students were working to produce, improve and prioritize their questions. Six students were selected, based on their academic achievement level, to participate in interviews that questioned their experiences in the QFT. Of the six students interviewed, two had demonstrated low levels of achievement in science since the beginning of the academic year, two had demonstrated moderate levels of achievement, and the remaining two were consistent high achievers. Additionally, all students participated in a survey that enabled them to anonymously express their feelings about how the intervention affected their ability to ask better questions.

The second focus question of this AR was: Will the generation of good questions improve students' ability to comprehend readings? Data connected to this question was collected by means of pre- and post-assessments utilizing ReadWorks paired readings, providing a comparison between scores and comprehension levels. Additionally, implementation of non-textbook science reading was incorporated, requiring students to read a science current events article of their choice and present their understanding to their classmates. Finally, students were surveyed regarding how they felt their reading comprehension was affected by implementation of the QFT.

The last focus question of this AR was: Will training in question generation improve students' ability to answer open-ended response assessment questions? Data was collected through means of pre- and post-assessment (open-ended responses), written lab

analysis questions, and attitude scales identifying how students felt that the QFT affected their ability to complete open-ended responses.

DATA AND ANALYSIS

The intent of this research was to determine if instruction in question generation impacts the ability of students to ask their own questions, and if it improves the quality of questions created. Additionally, the affect that training in question generation has on reading comprehension and answering open-ended responses was examined. A variety of data was collected, including observation of groups during the treatment, student interviews, student surveys, comparison of pre- and post-treatment reading assessments, current events article presentations, comparison of pre- and post-treatment open-ended test questions, laboratory analysis questions, and attitude scales. The treatment group in this project included the 34 students in my periods 2 and 3 classes, with the 45 students in my period 4 and 6 classes serving as the control.

Student Development of Better Questions

The development of good questioning was assessed through observational data, which included monitoring of student groups during the four intervention sessions and tallying the closed and open questions produced (Table 2). Every other Monday, the treatment classes received a new Question Focus, or “QFocus” that related to the content that was to be covered in the coming week. At the start of the intervention, all classes were beginning an eight-week unit titled “Body Works”, in which the human body systems, the organs, and their functions are examined. Sessions one, two and four featured QFocuses that were written prompts from which the students would develop

their questions, while the students viewed a demonstration in session three as their QFocus.

The students were very receptive to the QFT process and exhibited no difficulty staying on task during each of the four treatment sessions. In each session, question development was preceded by a review of the QFT rules. Most groups (7/9) produced more than ten questions during their first treatment session. After the formulation of questions was concluded in each session, a review of closed vs. open questions followed, including definitions and pros and cons of each. When asked to identify a benefit of open questions, one student suggested that “answering open questions lets people know what you know better than closed questions”. The students then identified their closed questions with a “C” and their open questions with an “O”. As shown in Figures 1 and 2 below, the groups completed the QFT process by identifying three questions that the group determined were their strongest, indicating them with an X or by circling the question. When asked about what the hardest part of the exercise was after the first session, one student shared that not commenting on questions being asked was a challenge. When asked to further explain, the same student explained “it’s hard not to say that someone had a really good question when you are impressed by what they wrote”.

1. When did colorectal cancer started? ○
2. Why did colorectal cancer start at ^{young} age? ○
3. How does it develop? ○
4. Can you die from it? C
5. Are there any side effect? C
6. If so, what are they? ○
7. Is there any cure for colorectal cancer? If so, what is it? ○
8. ~~Can you prevent it?~~ ^{How can you prevent it?} ○
Can you prevent it? ○
9. Will the age increase or decrease in the future? ○
10. How do you know if you have colorectal cancer? ○
11. Can it affect pregnancy? C
How can it affect pregnancy? C
12. Can it affect other organs? ○
13. Is it contagious? ○ C
14. Can a baby be born with it? Can it affect them? ○

Figure 2. Sample QFT results from Group 4, showing questions formulated from QFocus 4.

As expressed in Table 2, the average percentage of open questions written increased from the first treatment session (QFocus 1) to the last (QFocus 4) by 20.45%. The first QFocus yielded a mean score of 50.88% of the total questions being open, with a standard deviation of 0.19. The last QFocus yielded a mean score of 71.33% of the total questions being open, with a standard deviation of 0.114. Inversely, the average number of questions asked per treatment saw a decline from the first session to the last. The first QFocus yielded a mean of 13.44 questions asked, with a standard deviation of 3.6. The last QFocus yielded a mean of 10.55 questions asked, with a standard deviation of 2.06. When asked following the last treatment how their questioning had changed, one student shared that he “started putting more thought into the questions that asked, instead of just making lists of questions”. When asked further, the same student elaborated “I started to think about what I could actually learn from the questions that I ask”.

Table 2
QFT Results Comparisons (N=34)

Group	QFocus 1		QFocus 2		QFocus 3		QFocus 4	
	Question Total	% Open Questions	Question Total	% Open Questions	Question Total	% Open Questions	Question Total	% Open Questions
1	21	29%	15	73%	15	40%	8	63%
2	13	92%	6	50%	6	30%	10	70%
3	8	63%	10	80%	10	40%	12	75%
4	11	45%	8	50%	11	36%	14	64%
5	15	53%	10	80%	7	71%	9	89%
6	15	40%	8	25%	16	19%	13	69%
7	13	31%	11	64%	15	13%	11	91%
8	14	50%	11	64%	16	19%	9	55%
9	11	55%	13	62%	10	60%	9	66%
Average	13.44	50.88%	12.22	60.88%	11.77	36.44%	10.55	71.33%

Student interviews provided much insight as to how the students in the treatment group felt about asking questions and the QFT process that was selected to improve their formulation of questions (Appendix B). Three students were selected from each class included in the treatment group, comprising six students in total. Of the six students participating in the interview, two had demonstrated low levels of achievement since the beginning of the academic year, two had demonstrated moderate levels of achievement, and the remaining two were consistent high achievers.

When asked what they learned from their participation in the QFT, one student contributed that, as a result of the process, she learned “how to ask questions about the topic and stay on topic”. All of the students interviewed felt that they learned about questioning through the process, with one student sharing that it helped her ask more intelligent questions. In response to the second interview question, *Why is learning to ask your own questions important for learning?*, one student felt that benefitting others was an important result, while another stated that “one day you won’t have teachers anymore, but you should still ask questions and learn on your own.” Most of the students (5/6) shared that they felt more comfortable asking questions in class as a result of their participation in the QFT process, with one student elaborating that he no longer hesitates to ask questions. Another student shared that he felt more inquisitive about the class content after the process than he did before. Half of the students interviewed expressed a fear of judgment by classmates while asking questions in class prior to the treatment, sharing an increase in confidence after. Of these three students, one elaborated that the QFT process helped her to word her questions better, reducing her fear of judgement by

classmates. Each of the students interviewed felt that the benefits of the QFT extended past the confines of their middle school science classroom, with students suggesting that learning to ask good questions would benefit them in college and throughout future employment.

To assess how student confidence was affected by training in question generation, student surveys ($N=34$) were conducted before and after the treatment (Appendix C). Responses using weighted averages on a four point Likert scale were used to compare self-confidence in asking questions before and after the treatment. The results reveal that self-confidence in asking questions was positively impacted by the treatment (Figure 3). Two of the five survey questions reveal positive gains ranging from 0.23 to 0.3 in the weighted average, with the greater of the two seen in the survey question, *I have questions about the world around us that I'd like to find the answers to*. The result of this survey question ties into one of the responses provided in the student interview, suggesting that training students to ask better questions increases their curiosity about science.

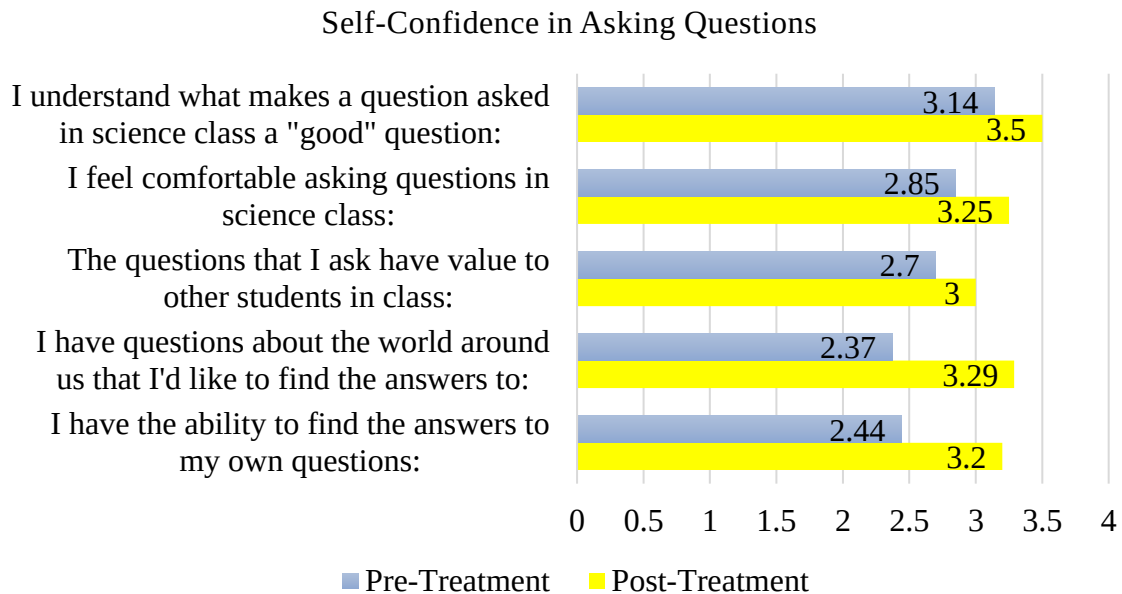


Figure 3. Comparison of student responses to the Self-Confidence in Asking Questions Survey (Pre-Treatment vs. Post-Treatment), ($N=34$). *Note:* Weighted averages on a 4 point Likert Scale: 1 = not confident at all and 5 = very confident.

Improvement in Ability to Comprehend Readings

The effect of training in question generation on students' ability to comprehend readings was measured using reading assessments, student presentations on science current events articles, and student surveys.

ReadWorks reading passages with paired questions were used to assess reading comprehension skills before and after the treatment period. Prior to the start of the treatment, coinciding with the completion of one unit, both treatment and non-treatment groups read a selected passage and completed multiple choice questions in order to determine if the QFT process affected the treatment group's ability to comprehend readings (Appendix D). The post-treatment assessment was administered to both groups eight weeks after the pre-assessment, after four sessions of QFT training had concluded

(Appendix E). Both ReadWorks assessments were designed for the 7th grade student, were identified as being on a Lexile level of 1080, and were paired with 6 multiple choice comprehension questions.

As shown in Figure 4, both treatment ($N=34$) and non-treatment groups ($N=45$) demonstrated improvement in their ability to comprehend readings using the assigned passages. The difference between the average pre- and post-assessment scores, however, was more substantial with the treatment group. The treatment pre-assessment had an average score of 73.53%, with a standard deviation of 16.89. The post-assessment average increased to 79.29%, with a standard deviation of 10.76. The non-treatment pre-assessment average was higher than the treatment, at 82.91% with a standard deviation of 16.01. They did demonstrate an increase in their average post-assessment score, as well, increasing to 84.4% with a standard deviation of 17.89. After the intervention, the treatment group saw a 5.76% increase in their assessment score, whereas the non-treatment group demonstrated a lower average rate of improvement at 1.49%.

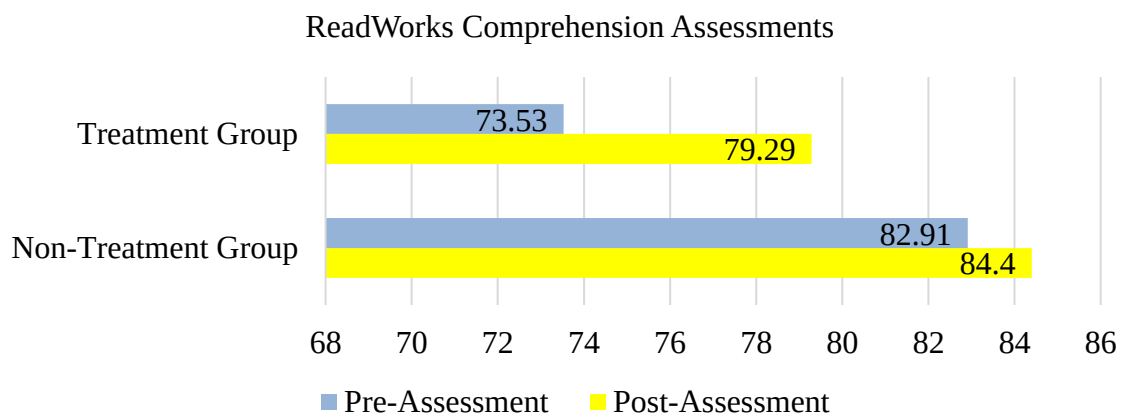


Figure 4. Comparison of comprehension pre- and post-assessments between the treatment ($N=34$) and non-treatment group ($N=45$).

To further assess how training in question generation affects a student's ability to comprehend readings, current events presentations were implemented. Prior to the start of the treatment, both treatment and non-treatment groups selected an online science news article of their choice, and prepared a Google Slides presentation identifying the five W's (who, what, when, where, and why) on individual slides. Students in both groups presented their work to their peers, and were assessed solely on the content of their slides and their ability to communicate scientific literature. As seen in Figure 5, the treatment group showed an improved average score from pre-treatment to post-treatment, increasing from 84.77% to 85.31%, and the non-treatment group saw a decline in their average score from 89.8% to 88.04%. The differences between average grades of the two groups' current events presentation ranged from 0.54% (treatment group) to -1.76% (non-treatment group), which cannot be determined to be a significant difference.

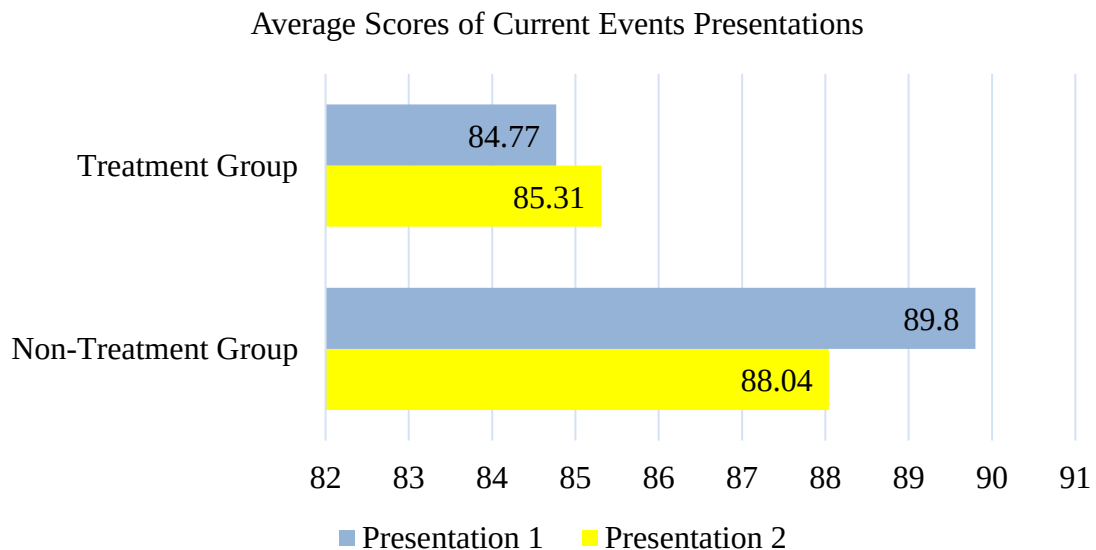


Figure 5. Comparison of current events presentations, pre- and post-treatment, between the treatment ($N=34$) and non-treatment group ($N=45$).

To assess how student confidence in reading comprehension was affected by training in question generation, treatment group student surveys ($N=34$) were conducted before and after the intervention (Appendix F). Responses using weighted averages on a four point Likert scale were used to compare self-confidence in reading comprehension before and after the treatment. The results (Figure 6) reveal that self-confidence in reading comprehension was positively impacted by the treatment. Four of the five survey questions showed positive gains of 0.08 and under. The greatest normalized gain, at 0.134 in the weighted average, was seen in the survey question, *When I identify words that I don't understand, I can successfully investigate their meaning.*

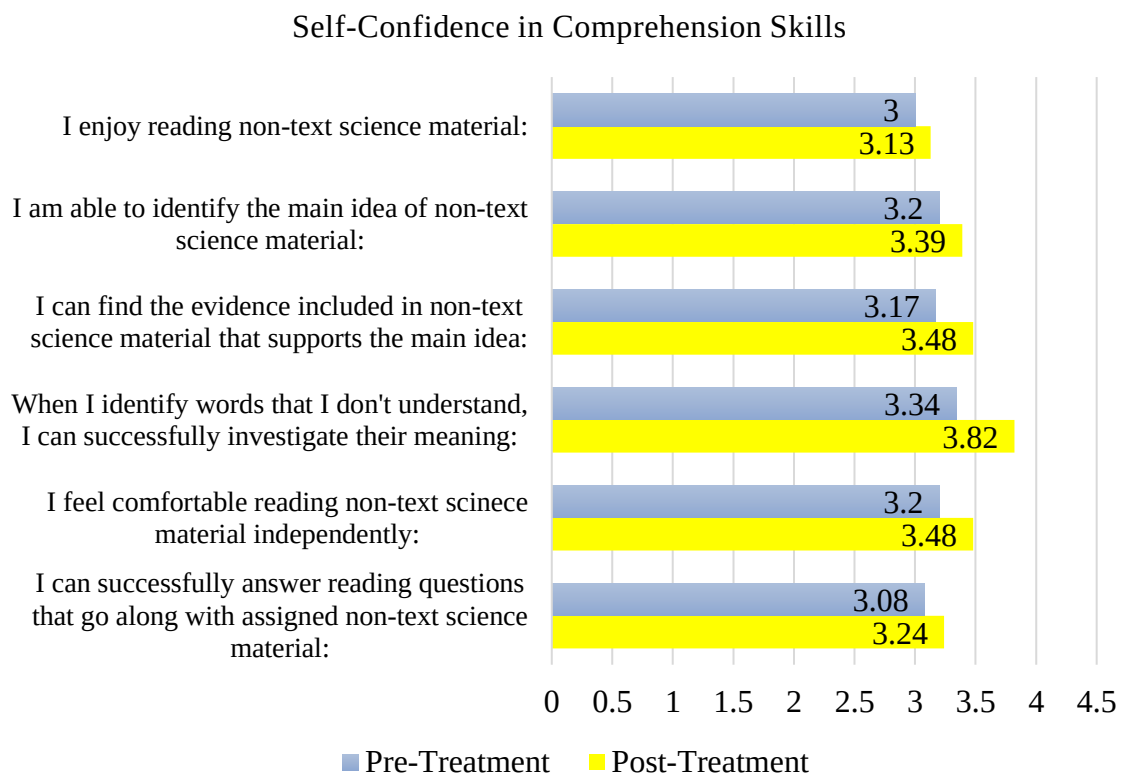


Figure 6. Comparison of student responses to the Self-Confidence in Comprehension Skills Survey (Pre-Treatment vs. Post-Treatment), ($N=34$). *Note:* Weighted averages on a 4 point Likert Scale : 1 = not confident at all and 5 = very confident.

Improvement in Ability to Answer Open-Ended Response Assessment Questions

The effect of training in question generation on students' ability to answer open-ended response assessment questions was measured by comparing unit summative assessment open-ended responses, lab analysis questions, and attitude scales.

The open-ended responses from the unit test that preceded the intervention served as the pre-assessment for both the treatment and non-treatment groups. Prior to the intervention, understanding of the objectives of the cell unit was assessed using both multiple choice and open-ended response questions. The open-ended portion of the test provided pre-assessment data for this focus question. The average scores of the pre-treatment summative assessment open-ended responses were compared to the average scores attained on the open-ended portion of the summative assessment for the unit that coincided with the treatment period. Since the treatment period spanned the duration of the body systems unit, the open-ended response used for its summative assessment was used for comparison between treatment and non-treatment groups. All open-ended responses were graded using the Understanding Concepts Rubric (Appendix F).

As shown in Figure 7, both treatment ($N=34$) and non-treatment groups ($N=45$) demonstrated improvement in their ability to answer open-ended response questions on summative assessments. The treatment pre-assessment yielded an average score of 80.7%, with a standard deviation of 14.26. The post-assessment average increased to 89.36%, with a standard deviation of 11.97. The non-treatment pre-assessment average was higher than the treatment, at 83.09% with a standard deviation of 13.88. They demonstrated an increase in their average post-assessment score, as well, increasing to

86.93% with a standard deviation of 12.67. The treatment group displayed a more significant improvement in their scores, as the average of their responses improved 8.65%, more than doubling the non-treatment group's improvement of 3.84%.

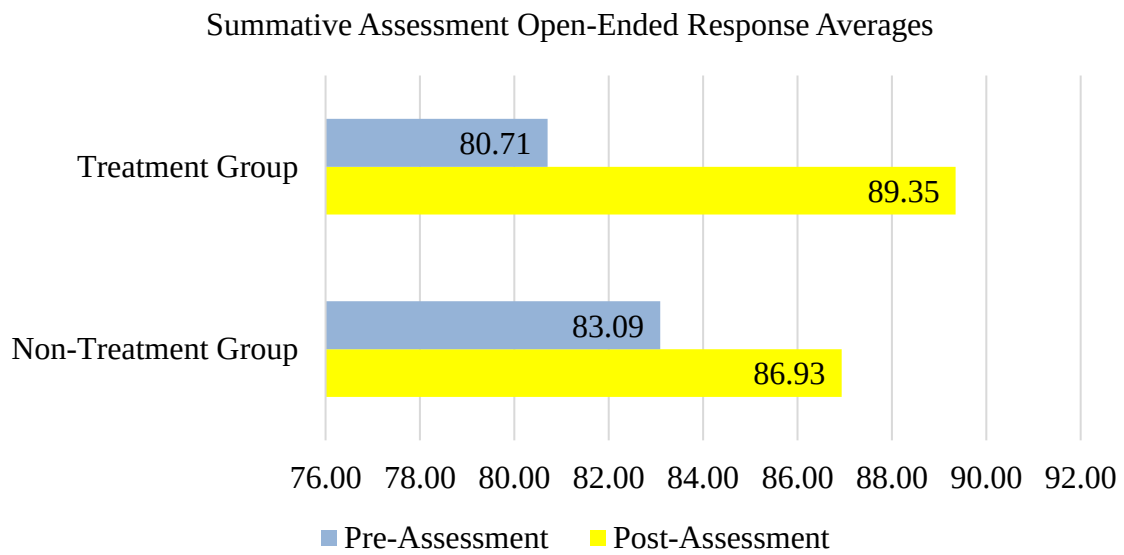


Figure 7. Comparison of open-ended pre- and post-assessments between the treatment ($N=34$) and non-treatment group ($N=45$).

Throughout the course of the intervention, the body systems unit continued as planned, with students in both the treatment and non-treatment groups conducting laboratory investigations and the work associated with them. The open-ended laboratory analysis questions that concluded the scheduled investigations were assessed using the Understanding Concepts Rubric (Appendix G). As seen in Figure 8, the average scores of both the treatment and non-treatment groups on open-ended lab analysis questions improved throughout the intervention, with the treatment group displaying the greatest improvement. The average score of the treatment group's lab analysis open-ended responses increased from 68.9% on the first assessment to 86.71% on the last, an increase

of 17.81%. The non-treatment group, however, saw an increase of 5.26% from their first lab analysis assessment's average of 77.87% to their last, which averaged 83.13%.

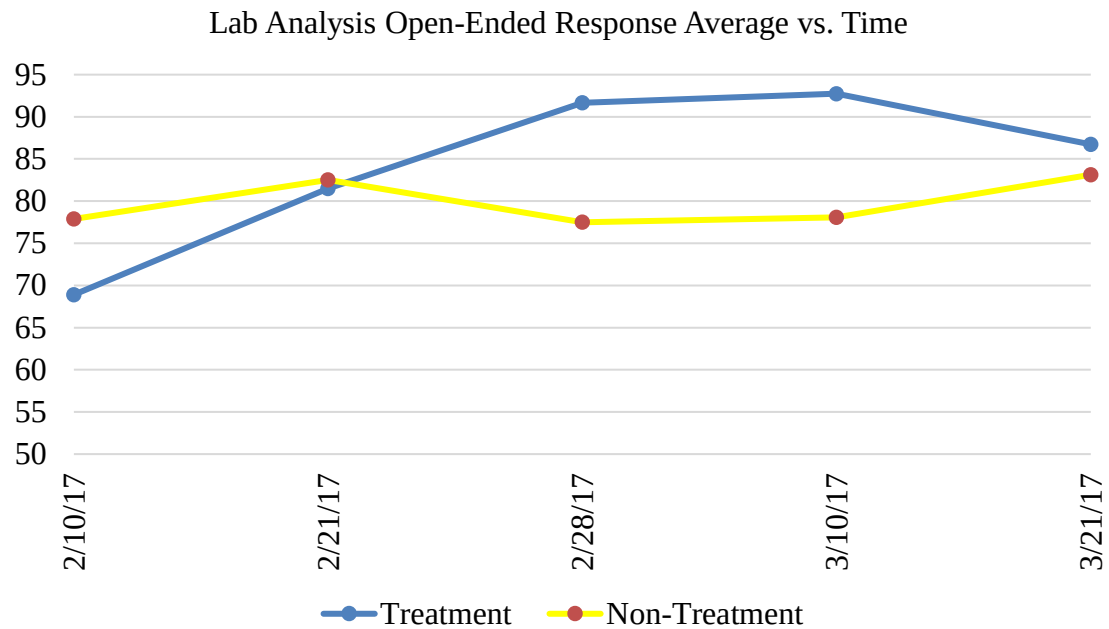


Figure 8. Comparison of treatment ($N=34$) and non-treatment ($N=45$) lab analysis open ended questions during the intervention period.

To assess how student attitude towards open-ended responses was affected by training in question generation, treatment group student surveys ($N=34$) were conducted before and after the intervention (Appendix H). Responses using weighted averages on a five point Likert scale were used to compare attitude towards open-ended responses before and after the treatment. The results (Figure 9) reveal that feelings towards open-ended questions were minimally impacted by the treatment. Normalized gains for survey questions ranged from 0.01 - 0.06, with the exception of the question, *Open-ended questions are challenging to answer*. The indicated question saw a normalized gain of -0.03, indicating that the attitude towards the challenge of open-ended questions shifted in

a slightly positive direction. With a 3 on the 5 point Likert scaled indicating a neutral attitude towards open-ended responses, the averaged results reflect the students lack of caring either way about their assessment question format.

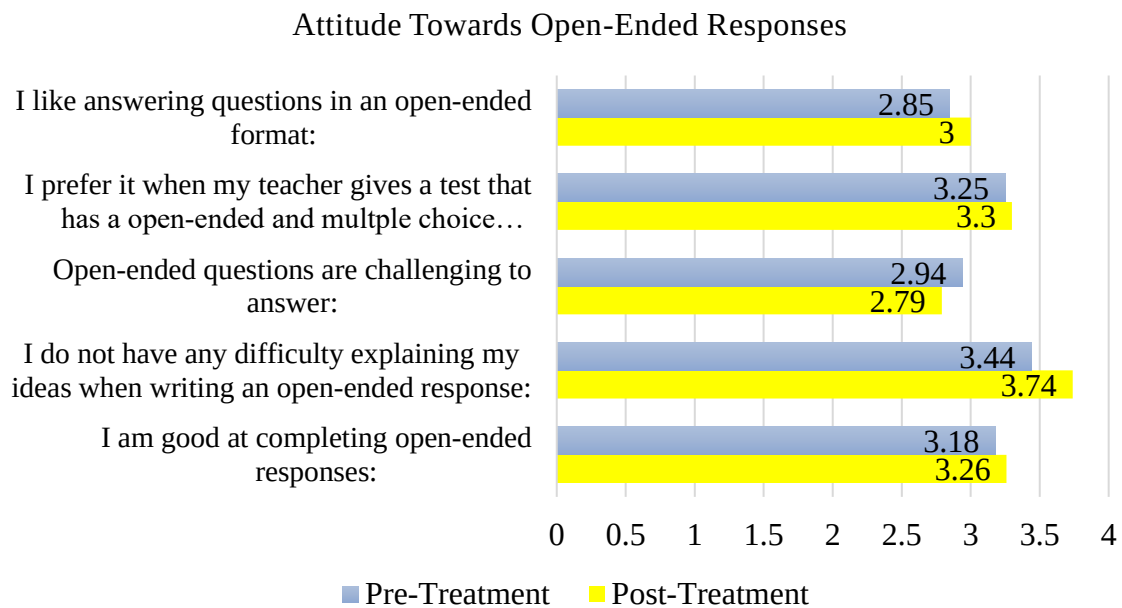


Figure 9. Comparison of student responses to the Attitude Towards Open-Ended Responses Survey (Pre-Treatment vs. Post-Treatment), ($N=34$). *Note:* Weighted averages on a 5 point Likert Scale: 1 = strongly disagree and 5 = strongly agree.

INTERPRETATION AND CONCLUSION

As previously stated, the intent of this research was to determine if instruction in question generation impacts the ability of students to ask their own questions, and if it improves the quality of questions created. The data collected and analyzed provides evidence that the Question Formulation Technique positively affects student questioning and their development of better questions, as well as other academic skills investigated.

The increase in average number of closed questions asked in each treatment session throughout the course of the intervention indicates that the students included in

the treatment were developing a higher concentration of “better”, or meaningful and researchable, questions (Table 2). One student had shared that it was hard to follow all of the QFT rules, specifically the one that prohibits group members from commenting on the questions that others develop and list, and I wholeheartedly agree. As I circulated the classroom throughout each treatment session, I was impressed by the questions that I was hearing group members share, and I found it challenging as the facilitator to keep my comments and praise for student questioning to myself. Additionally, as the average number of questions decreased in each treatment session, I observed that the participants were putting more thought into their questions, rather than playing a classroom version of 20 questions. Stimulating the questioning process with thought and meaning in a directed manner can lead to deeper learning of the material presented while making connections that are relevant and interesting to the student.

Of the students interviewed at the conclusion of the intervention, five of the six expressed an increase in confidence in asking questions in class. In middle school, many students hesitate to ask questions and participate in class due to a variety of factors, including innate shyness, fear of judgment, or simply not knowing how to ask their questions. The treatment’s improvement in the question-asking confidence and comfort level of the students involved will aid in their learning throughout all academic areas, not just science. Of all the benefits of the treatment, the increase in confidence in question asking rings the most valuable to me.

A “good” question can be defined as one that is researchable, induces learning, and enables the student to make connections between new material and prior knowledge

(Cuccio-Schirripa & Steiner, 2000). Based on these criteria, the QFT was a successful method by which to train students to ask better questions. By selecting QFocus questions that were relevant to the week's content, students were able to develop questions that were personally meaningful, for a multitude of reasons. These questions then became the springboard for the customized learning and discussion within the classroom that further fueled the inquiry process.

The effect that training in question generation has on student ability to comprehend readings was investigated and found to have a small, yet positive impact. The results of the comparative ReadWorks reading comprehension assessments yielded greater improvement in the average test scores of the treatment group than the non-treatment group (Figure 4). The results of the comparative current events presentations yielded small, yet positive results for treatment group, with the difference between their average pre- and post-treatment scores equating to 0.54%. The non-treatment average scores declined by 1.76%. The lack of a trend in both sets of data, either positive or negative, leads me to conclude that further assessment is required to determine if training in question generation improves student ability to comprehend readings.

Results from the data collected to determine if training in question generation improves student ability to answer open-ended questions were found to be positive, with gains made in both the unit assessment open-ended responses and the laboratory analysis open-ended responses. As with the comparative ReadWorks average scores, both the treatment and non-treatment groups saw improvements in their average open-ended scores (Figure 7). The treatment group, however demonstrated an increase in average

summative assessment open-ended responses more than doubling that of the non-treatment average difference. With the data collected from the laboratory analysis open-ended questions in agreement with that of the unit assessment's, training in question generation has demonstrated a positive impact on this skill.

Direct instruction with application of teacher-generated questions has been seen to facilitate understanding of content attainment, but lies low on Bloom's taxonomy of cognitive development (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956).

Implementation of the QFT evoked a positive outcome in open-ended responses by enabling the students to delve deeper into their learning and express the higher cognitive development that results from students developing their own questions (Cuccio-Schirripa & Steiner, 2000). Because developing their own questions was more meaningful to them and connected what they learned to prior knowledge and personal experience, the students who were treated with the QFT were able to produce more thorough and connected open-ended responses, rather than just reiterating content.

VALUE

The implementation of training in question generation, and more specifically the Question Formulation Technique, has benefitted my teaching and my pedagogical perspective greatly. Primarily, the process has opened my eyes to realize that not only is the teaching the curriculum's content important, but also that teaching students how to think and ask questions is equally, if not more, important. The thought of encouraging students to explore, ask questions, and develop their own path towards inquiry is inconceivable to many educators, as it once was to me. The data collected through this

classroom research shows me that learning does occur when the students influence where they want to go within the content, and it is often more meaningful and longer-lasting than when the teacher directs the path without any influence.

Just like any skill, students must be taught how to formulate questions that benefit their learning and the learning of others. Without understanding how an open question derives more detail and explanation than a closed question does, a student may not recognize the importance of asking good questions that spark their level of curiosity nor may they realize that they actually have good questions within them. Instruction in any skill is pertinent to successful practice and implementation of it, and the formulation of one's own questions is no different.

One argument against student-centered science that I often hear within the confines of my department is that the students lack the ability to truly make their inquiry meaningful, and that other skills will slip by the wayside as the students veer away from the traditional teacher-led classroom and line of inquiry. I have always understood those concerns, and now know that there is a way to work with them. I greatly look forward to sharing my findings with my colleagues, showing them that our students have the ability to ask meaningful questions, and that developing this ability will lead to improvement of other skills, as well.

Going forward, the implementation of the QFT is one that I will begin the school year with in September. Not only does the training improve the quality of questioning by the students, which is essential as my district transitions to implementing the Next Generation Science Standards, but it also increases the confidence of students who

otherwise may hesitate to ask questions in class or propose a direction for a student-directed inquiry activity. My students responded with a great level of positivity each time we worked on a QFocus, worked collaboratively to develop good questions, and were truly proud of their accomplishments. The discussions that took place after the questions were listed and the strongest ones identified were priceless. Instead of my students listening to me direct them in what I found interesting, I was able to learn more about how my students think and what, within our topic of study, they were curious about. By starting the process at the beginning of the year, I foresee the gains from the intervention taking hold much earlier and more consistently than during my classroom research project.

As I reflect on the results of this investigation, I begin to plan for the 2017-2018 school year. To derive a greater sense of the impact that training in question generation has on student the quality of questions asked in class, reading comprehension, and answering open-ended responses, implementation with data sets comparing the 2016-2017 pre-intervention to 2017-2018 intervention within the same units of study would be necessary. This may alleviate some questions that did arise during the intervention, as pre-assessment and post-assessment data was based on two different units of study, cell and then body systems. As I compared the pre-treatment and post-treatment data, I did question if students performed better on post-assessments towards the end of the body systems unit, as they are more familiar with their own bodies, as compared to the pre-assessments that were based on content from cell unit, one that is less relatable or meaningful to them. Additionally, I would like to explore how the questions developed

during QFocus sessions could best be used to further the learning and inquiry of my students.

Finally, after working with my science department, I would like to take the strategies implemented in this classroom research to other content areas within my school. Asking questions is a skill that is not isolated within the science laboratory, rather it is one that is of benefit across all classrooms. In addition to continuing to further question development in science, language arts, math, and social studies, implementation of a shared method will enable our students to reap all the benefits much sooner by working in a collaborative manner.

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APPENDICES

APPENDIX A
INSTITUTIONAL REVIEW BOARD APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Crista Tiboldo's and Eric Brunsell
FROM: Mark Quinn *Mark Quinn CJ*
DATE: December 2, 2016
SUBJECT: "The Effect of Training in Question Generation on the Development of Better Questions Posed by Seventh Grade Science Students" [CT120216-EX]

The above research, described in your submission of December 2, 2016, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

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

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

APPENDIX B
INTERVIEW QUESTIONS

Participation in this interview is voluntary. Choosing to participate or not participate in this exercise will not affect a student's grade or class standing.

Science Interview Questions

1. What did you learn from your participation in the Question Formulation Technique?
2. What makes a question "good"?
3. Why is learning to ask your own questions important for learning?
4. How do you feel now about asking questions? Is this different than your feelings before participating in the technique?
5. How can you use what you learned about asking questions?

APPENDIX C

SELF CONFIDENCE IN ASKING QUESTIONS STUDENT SURVEY

Participation in this survey is voluntary. Choosing to participate or not participate in this exercise will not affect a student's grade or class standing in any way.

This survey is intended to understand your level of confidence in your ability to ask questions in our science class.

	How confident do you feel? (circle one)			
1. I understand what makes a question asked in science class a "good" question.	Very	Somewhat	Not very	Not at all
2. I feel comfortable asking questions in science class.	Very	Somewhat	Not very	Not at all
3. The questions that I ask have value to other students in class.	Very	Somewhat	Not very	Not at all
4. I have questions about the world around us that I'd like to find the answers to.	Very	Somewhat	Not very	Not at all
5. I have the ability to find the answers to my own questions.	Very	Somewhat	Not very	Not at all

APPENDIX D
READWORKS PRE-ASSESSMENT

Why Humans Can't Live Off Sunlight

By ReadWorks

In 2013, a resident of Seattle, Washington, named Naveena Shine decided that she would embark on an experiment. Shine had become fascinated with photosynthesis, the process by which plants are able to make their own food using sunlight. Sunlight contains a significant amount of energy, which plants are able to use to convert water, carbon dioxide, and minerals into oxygen and organic compounds, including nutrients like glucose. Shine reasoned that the human body, if forced to, could do the same thing. So Shine set out to test her hypothesis. In May, she declared that, for the next six months, she would not eat food. Instead, she would limit her diet to only sunlight, water, and tea.

Shine saw her experiment as an important moment in human history, perhaps even a next step in the evolutionary process. On her website, she outlined the many potential advantages of humans being able to produce their own food from sunlight: people would not have to work as hard to earn money to buy food; instead of cooking and shopping, they would have more time to do other things, and many of the earth's natural resources used in the production and preparation of food would be saved for future generations. And why wouldn't it work?

"Plants live on light, and then we eat plants," she concluded. "Are we simply not accessing our inherent ability to live on light?"

Shine also claimed that several people had successfully lived on light before her. She cited a German chemist named Michael Werner, who claims to have eaten no food since 2001, and Ellen Greve, an Australian spiritual leader—known to her followers as Jasmuheen—who said she had not touched a meal since 1993. (These claims were never proven true.) To prove that she was not sneaking food to eat, Shine said she would set up eight video cameras in her trailer to record her every movement. On May 3, 2013, with her predecessors in mind, Shine began her experiment.

The results were dramatic, although perhaps not in the way Shine had planned. Over the next five weeks, Shine lost 30 pounds, dropping from 160 pounds to 130. She felt weak and occasionally had difficulty standing. She reported that when she went outside to get her daily regimen of sun, her hands were cold. Shine predicted that this would be the moment when her body would produce its own food.

"I have the feeling my body has reached a point where it has used up all its stored fats, and is now looking around for what to consume next," she wrote on Facebook. "I suspect this might be the point where it decides either find and hook into the source where it is able to live on light, or consume the body for sustenance."

Shine's experiment received a lot of criticism. Many of her detractors pointed out that, even if her hypothesis was valid, famously cloudy Seattle might not have been the best place to test it out.

On June 19th, after 47 days of the experiment, Shine called it quits. She had lost 33 pounds and was having difficulties holding down water in her stomach. However, Shine did not rule the experiment a failure. Instead, she blamed the early termination on several other, more practical factors, including a lack of funds. Shine had charged the cameras in her trailer to her credit cards. She had expected that visitors to her website would donate funds to pay for the cameras and sustain her experiment. However, after 45 days, she had received only \$435, forcing her to leave her trailer and return to work. She also cited the overwhelmingly negative reaction to her experiment as another reason for its termination.

"From the feedback I am getting," she wrote, "it is becoming patently clear that most of the world is by no means ready to receive the information I am attempting to produce."

Shine appears to have escaped from the experiment without permanent damage—although she did sustain a steep drop in her weight and some credit card debt. However, starving yourself can do serious harm to the body and is very dangerous. Others who have attempted the same experiment have not been so lucky. At least four people, inspired by similar teachings about the nutritional value of sunlight, have died from self-inflicted starvation. Starving is dangerous because when the body is deprived of vital nutrients, it begins to shut down some of its vital organs, greatly increasing the chances of illness. If deprivation lasts long enough, then the person can sustain long-lasting injuries or even die.

What was Shine's mistake? Well, she made several. Most importantly, she misunderstood how energy is produced in plants versus how it's produced in humans. While sunlight does indeed contain energy, only plants are able to render this energy into a usable form. Dr. Ronald Hoffman, a clinician and spokesman about health and nutrition, told the UK's *Guardian* newspaper that Shine's ideas were "delusional" and explained her error.

"Plants have what are called chloroplasts that contain chlorophyll, and they have the ability to capture energy from sunlight," Hoffman said. "Humans don't have chlorophyll or chloroplasts. No humans do. It is impossible for a human to have that."

A chloroplast is a structure that is able to produce a very specific chemical reaction in which plants use light energy and carbon dioxide to produce sugars. A chemical reaction is when atoms of one substance are rearranged to make a different substance. During photosynthesis, carbon dioxide atoms the plant draws from the air are split into carbon atoms and oxygen atoms. The carbon atoms are used by the plant to make sugar, a form of carbohydrate. (Carbohydrates are compounds made of carbon, hydrogen, and oxygen.) The plant then discards any oxygen it does not use as a waste product. This is much like how human beings breathe out carbon dioxide as a waste product of our own bodily system.

The sugars plants produce during photosynthesis are of a form that plants can use to survive and grow. In this way, the energy that is contained in sunlight is transformed into a different kind of energy. However, the structures capable of making this transformation—chloroplasts—are present only in plants, not humans. When Shine concluded that her experiment would work because plants live on energy from the sun and people eat plants, she was not recognizing that humans do not eat sunlight; people eat the sugars that plants produce. For example, if people eat sweet strawberries, they are not eating the energy from the sun. They are eating a kind of fruit sugar, called fructose, that the strawberry plant produces. If Shine had had a better understanding of photosynthesis and how the human body works, she probably would not have believed her experiment would work.

1. As part of an experiment, what did Naveena Shine limit her diet to?
 - A sunlight, water, and tea
 - B sunlight, sugar, and water
 - C sunlight, water, and fruit
 - D water, fruit, and tea
2. This text is organized into two main parts. The first part describes Naveena Shine's experiment and its results. What does the second part mostly describe?
 - A how Naveena Shine has reacted to criticism of her experiment
 - B the process by which plants produce energy
 - C the long-term and short-term symptoms of organ failure
 - D the process by which humans extract energy from the plants we eat
3. Even after her experiment, Shine believed that humans could live on sunlight. What evidence from the text best supports this conclusion?
 - A "What was Shine's mistake? Well, she made several. Most importantly, she misunderstood how energy is produced in plants versus how it's produced in humans."
 - B "So, Shine set out to test her hypothesis. In May, she declared that, for the next six months, she would not eat food."
 - C "Shine appears to have escaped from the experiment without permanent damage—although she did sustain a steep drop in her weight and some credit card debt."
 - D "Shine did not rule the experiment a failure. Instead, she blamed the early termination on several other, more practical factors[.]"
4. How can the tone of this article best be described?
 - A confused and slightly annoyed
 - B explanatory and slightly condescending
 - C sarcastic and very goofy
 - D enthusiastic and excited
5. What is the main idea of this text?
 - A Many people have claimed to live off only sunlight, but none of these claims have been proven true.
 - B Because plants can live off sunlight and water, they are further along in the evolutionary process than humans.
 - C A woman tried to live off sunlight like plants do, but failed because humans and plants produce energy differently.
 - D Plants produce food through a process called photosynthesis, using sunlight, water, carbon dioxide, and minerals.

6. Read these three quotes from Naveena Shine from the text.

"Plants live on light, and then we eat plants,' she concluded. 'Are we simply not accessing our inherent ability to live on light?'"

"I have the feeling my body has reached a point where it has used up all its stored fats, and is now looking around for what to consume next,' she wrote on Facebook. 'I suspect this might be the point where it decides either find and hook into the source where it is able to live on light, or consume the body for sustenance.'"

"From the feedback I am getting,' she wrote, 'it is becoming patently clear that most of the world is by no means ready to receive the information I am attempting to produce.'"

Why might the author have included three quotes from Naveena Shine?

- A** to express the author's agreement with Shine's ideas and opinions
- B** to share Shine's ideas and opinions with the reader directly
- C** to show that Naveena Shine's conclusions were accurate
- D** to suggest that Shine has a better understanding of science than the author

APPENDIX E
READWORKS POST-ASSESSMENT

Study Buddies

By Meredith Matthews

Teens talk about being part of medical trials—or not.

The next time you pop a pill for a backache or a cold, check out the label. It may say the drug is safe and effective for ages 12 to adult. But how does the drug's manufacturer know whether it's good for you? Have scientists ever studied it in teens?

In some cases, the answer is no. Many treatments—drugs, devices, and techniques such as surgeries—have been well tested in adults but not in teens. That's changing, though, as health officials encourage more research in young people.

More Info, Please

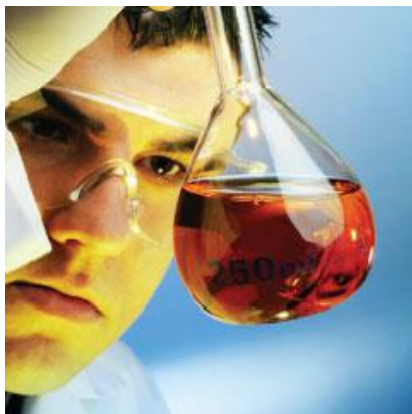
Health providers need to know the best way to help teens with problems. And that information has been hard to find. Most products aren't developed for or tested in this age-group, according to the U.S. Food and Drug Administration. The Best Pharmaceuticals for Children Act, renewed in 2007, seeks more research of health products in kids and teens.

Researchers aren't wasting any time getting young people involved. Perhaps half the patients in Seattle Children's Hospital's Adolescent and Young Adult Cancer Program take part in trials, according to Dr. Rebecca Johnson, the program's medical director. Some studies aim to help teens beat an illness; others test treatments that might have fewer toxic side effects than current treatments.

Why bother? There's a common saying among scientists who study teens: "Children are not little adults." Teens' bodies differ from those of both older and younger people. Their organs work like kids' organs, but their hormone levels are closer to those of adults, so treatments can cause more side effects, says Johnson. That's not the only reason more research is needed. Many cancer treatments affect future fertility—the ability to have children—which is a "huge consideration in adolescents," Johnson notes.

Problems such as high blood pressure that used to affect mainly adults are occurring in a growing number of teens. "We don't have the option of *not* treating the disease, but we don't know the best way *to* treat it," says Dr.

Michael Spigarelli, medical director of clinical trials in Cincinnati Children's Hospital's adolescent medicine division.



iStock

So researchers create studies, many of which are helping teens. Between 1975 and 1995, cancer deaths in kids and teens dropped nearly 40 percent. That change is "really the result of clinical trials," says Dr. Yoram Unguru, a childhood cancer specialist at Johns Hopkins University in Baltimore.

Tough Decisions

Those successes don't mean a trial is a shortcut to a cure. A participating teen might be in the control group that doesn't get the treatment being studied. (Control groups help researchers see how something new stacks up against the current best treatment.) Or the treatment may not work well. Teens participating in clinical trials are taking "a huge leap of faith," admits Unguru.

No one can force people to join studies. Those younger than 18 can't decide on their own to take part—parents or guardians have to sign a consent form. But researchers want teens to have a say and exclude those who don't want to participate. Unguru and his colleagues asked kids and teens who took part in studies about their experiences; pressure from parents and doctors to participate was common. However, when teens have a role in the choice—they provide assent, as opposed to legal consent—it's "empowering ... because so many [other] decisions are taken out of their hands," Unguru says.

The chance to speak up meant a lot to Valery Y., 17, who learned in 2009 that she had leukemia, a blood cancer. Her doctors asked her to participate in a study of differing medication doses. "I didn't hesitate to say yes," the

Healthy People Help Too

You don't have to be sick to be in a study. Some clinical trials involve healthy people, either to test a therapy's effects or to serve in a control group that doesn't receive it. Some experiments track healthy people to see who develops problems. Cincinnati Children's Hospital studies everything from skin-care products to the relationships of teens and parents, says Dr. Michael Spigarelli, who directs the research.



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Some studies track how healthy teens are.

For instance, Brandi G., 15, from Kentucky, was in a study that looked at the circulatory systems of obese preteens and teens with type 2 diabetes. She isn't obese and doesn't have diabetes. Brandi was in the control group. Being in the study wasn't hard, she says. In addition to having blood drawn, body measurements taken, and heart and blood tests run, she filled in a food diary and wore an activity monitor. Brandi thinks her contribution will help "so there's more knowledge about teens."

Reasons for Rules

You won't find mad scientists running Frankenstein-like clinical trials. Many rules protect participants. For instance, trials have to be approved by an institutional review board—experts who ensure the study minimizes risk to participants.

Another requirement, informed consent, has been getting a lot of attention because of a recent book—*The Immortal Life of Henrietta Lacks*, written by Rebecca Skloot. It tells the story of Lacks, a young mother who died of cancer in 1951. In the hospital, samples of her tumors were taken without her knowledge or consent.

Scientists discovered that those cells stayed alive in the laboratory. Since the 1950s, cells that came from Lacks have become a mainstay of research. Scientists have used them for everything from developing the vaccine for polio to studying radiation poisoning.

Sounds terrific, right? But doctors did not ask Lacks or her family for consent to take or use her tissue. Her family members weren't compensated for the cells, which have made millions of dollars for private companies. Today, research protections make such a scenario far less likely.

1. Which of the following is not a reason teens opt to participate in trials?
 - A to improve their own health conditions
 - B to make money
 - C to contribute to the greater good
 - D to have a voice and have a say in things
2. The author presents evidence in this article for which of the following arguments?
 - A All teens should participate in medical trials.
 - B Teens should rarely participate in medical trials; they're too risky.
 - C It's a personal choice whether a teen should participate in a medical trial.
 - D Before a teen participates in a medical trial, he or she should talk to his or her parents and consider all the risks, benefits, and potential side effects.
3. Which of the following conclusions about children's and teens' involvement in medical trials is supported by the passage?
 - A Studies with younger people improve what we know about products and treatments.
 - B Involving children in the medical trials makes them feel better, even if the impact on our medical knowledge isn't large.
 - C There are too many risks involved in conducting studies with youth, so we should abolish these types of studies altogether.
 - D Children's and teens' involvement in medical trials is only helpful some of the time.

4. Read the following sentence: "However, when teens have a role in the choice—they provide assent, as opposed to legal consent—it's 'empowering ... because so many [other] decisions are taken out of their hands,' Unguru says."

The word **assent** means

- A reach the peak of
- B agreement
- C difference
- D data

5. This passage is mostly about

- A whether or not parents should sign their kids up to participate in medical trials
- B the challenges of recruiting young people to participate in medical trials
- C the impact of younger people's involvement, or lack thereof, in medical trials
- D the risks involved in participating in medical trials, especially for children and teenagers

8. The question below is an incomplete sentence. Choose the word that best completes the sentence.

Some teens choose *not* to participate in a trial _____ they're already exhausted from treatment after treatment and don't want to go through more.

- A also
- B because
- C although
- D however

APPENDIX F

SELF CONFIDENCE IN COMPREHENSION SKILLS STUDENT SURVEY

Participation in this survey is voluntary. Choosing to participate or not participate in this exercise will not affect a student's grade or class standing in any way.

This survey is intended to understand your level of confidence in your ability to read and understand assigned material in our science class.

	How confident do you feel? (circle one)			
1. I enjoy reading non-text science material (articles, passages, etc).	Very	Somewhat	Not very	Not at all
2. I am able to identify the main idea of non-text science material.	Very	Somewhat	Not very	Not at all
3. I can find the evidence included in non-text science material that supports the main idea.	Very	Somewhat	Not very	Not at all
4. When I identify words that I don't understand, I can successfully investigate their meaning.	Very	Somewhat	Not very	Not at all
5. I feel comfortable reading non-text science material independently, without teacher explanation.	Very	Somewhat	Not very	Not at all
6. I can successfully answer reading questions that go along with assigned non-text science reading.	Very	Somewhat	Not very	Not at all

APPENDIX G
OPEN-ENDED RESPONSE RUBRIC

Score	Description
100	Student accurately and completely explains or uses relevant scientific concepts.
87	Student explains or uses scientific concepts BUT has some omissions or errors.
74	Student incorrectly explains or uses scientific concepts.
65	Student presents a response, but does not answer the question.
NG	Student does not submit a response.

APPENDIX H

ATTITUDE TOWARDS OPEN ENDED RESPONSES SCALE

Participation in this survey is voluntary. Choosing to participate or not participate in this exercise will not affect a student's grade or class standing in any way.

This survey is intended to understand your feelings towards writing open ended responses in our science class.

Attitude Scale (circle one)					
1. I like answering questions in an open-ended format.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2. I prefer it when my teacher gives a test that has open-ended and multiple choice questions.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3. Open-ended questions are challenging to answer.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4. I do not have any difficulty explaining my ideas when writing an open-ended response.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5. I am good at completing open-ended responses.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree