THE EFFECTS OF EXPLICITLY TEACHING BLOOM'S TAXONOMY AND PROVIDING DIRECT STUDENT PRACTICE IN THE HIGH SCHOOL SCIENCE CLASSROOM TO INCREASE STUDENT SUCCESS AND CONFIDENCE ON HIGHER-ORDER THINKING

by

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ABSTRACT

This action research study aims to address the lack of critical thinking skills present in students observed during my 7 years of teaching both in Madison, WI and Telluride, CO and within a variety of science courses. The intervention was formally carried out with a group of 9th grade students at Telluride High School in Telluride, CO. The study utilized a descriptive model. Biology students were taught the ideas of Bloom's Taxonomy and questioning levels, then asked to apply these levels numerous times over the course of six weeks in three separate research projects related to the units of DNA and Protein Synthesis, Genetics, and Taxonomy. Pre- and post- surveys, interviews, and critical thinking tests were used to collect data. Students also reflected on pre- and post- questions they asked in their notes and in watching short video clips, such as a TED talk. Students reported higher understanding of elements of Bloom's Taxonomy and a deeper understanding in the areas their topics focused on. They additionally made gains in critical thinking and advancing the categories of questions that they chose to ask and answer on related topics.

INTRODUCTION AND BACKGROUND

Telluride Middle High School (TMHS) is located in Telluride, Colorado. The school resides in a small, quiet ski resort community located in the San Juan Mountains of the southwestern corner of the state. The community is composed of about two thousand full-time residents. TMHS serves approximately four hundred students from grades seven through twelve with about 260 students enrolled in the high school. About one fourth of those students are Latino/a with the vast majority of the school being Caucasian. Around a quarter of the school qualifies for free and reduced lunch. Telluride High School is regarded as one of the top public high schools in the state, with our average senior composite ACT score being a 24.1, and offering 17 Advanced Placement (AP courses) during 2017-2018. Our graduation rate is 87%, with 83% of Telluride graduates attending a four-year university after graduation (http://tmhs.tellurideschool.org).

I have been teaching for seven years. After graduating from the University of Wisconsin-Madison with a degree in biology and secondary science education, I taught for three years in the Madison Metropolitan School District. I then relocated to Telluride Middle High School where I have taught for four years. During my four years in Telluride, I have taught 8th grade science, freshman biology, AP biology, nutrition, environmental science, AVID, and 7th grade physical education.

Over the past years of teaching, I have become increasingly discouraged about my student's critical thinking skills when answering difficult questions. I have seen the students struggle with higher-order thinking questions. Last year was the first year that I

taught AP biology and it was tough watching my students struggle with questions that are challenging, they would assume a poor attitude and easily give up. These were presumably the highest achieving and college bound students. It was disheartening.

I began wondering if my teaching methods in the freshman biology class could help to encourage critical thinking skills necessary for successfully answering higher-level questions, and inspire success later in their education and beyond. Furthermore, this got me thinking about ways that I could help my students feel more successful and confident in their learning. If I could get students to embrace a challenge, take an academic risk, and understand the rational for how to ask and answer questions, then I thought they would buy-in more to their learning process and be more prepared for their college and careers that await them.

My previous observations led me to asking my action research (AR) question: Does explicitly teaching Bloom's Taxonomy and providing direct student practice increase student success on higher-order questions? My sub-questions included: What foundational skills do students need to complete higher-order thinking questions successfully? What activities can be used to teach higher-order thinking questions effectively? Do student test scores increase with exposure to teaching question decoding and Bloom's Taxonomy? Do student confidence levels increase with question exposure?

During the development and construction of this AR project, I had incredible help and support from my team. They understand teaching, learning, and me. The primary member is Derek Engebretsen, MS science, HS physics teacher, and my husband who is

concurrently progressing through the MSSE program as well. He acted as a sounding board, peer-editor, and emotional guide.

My team also consisted of Katrina Cornell, high school math teacher and graduate of the Montana State Math Master's Program. Katrina played a role when I was trying to crunch number data because of her strong math background. Erin Thompson, 6th grade teacher was key to emotional support and project brainstorming. She was a graduate of Telluride High School and also had just received her Master's Degree in Education. Erin brought a unique perspective as she is both a colleague and long-time local that knew our student body well. Finally, my Professional Learning Community (PLC), that met every other week, and was composed of many individuals, such as the ELA (English Language Acquisition) teacher, a history teacher, a technology teacher, a librarian, an English teacher, and a Spanish teacher helped glean insights. The PLC acted as a safe space to gather ideas from a diverse group of teachers for feedback.

CONCEPTUAL FRAMEWORK

As I began my search to delve into research related to developing critical thinking in students and scientists, I found that I was not alone in my quest to help address this deficit in students. One of the courses that helped me hone in on my AR question, primarily due to my disappointment and frustration, was (Advanced Placement) biology during my first year teaching the course, where I observed an inability of my "college-level" students to interact with the subject material at a deeper-level.

Authors Crowe, Dirks, and Wenderoth (2008), focused on the analysis of over 600 science questions that appeared on life science exams in college life science courses.

It became clear from this article that lower order cognitive skills (LOCS) or memorization and recall facts are being tested on most college exams, not higher order cognitive skills (HOCS). As a result, students are lacking HOCS and a deeper understanding of the information. The authors, recognizing a HOCS vs. LOCS deficit, developed a Blooming Biology Tool (BBT), to help educators ensure they are asking challenging tasks of students. Crowe et al. (2008), although not an action research, outlined uses and applications of Bloom's Taxonomy in science classrooms, and provided suggested timelines to implement skills related to Bloom's Taxonomy which frameworks the BBT. The research and BBT was constructed in hopes of creating a more fluid way to assess student content and skill mastery, and help provide collegiate faculty with a way to better align their assessments and learning objects.

Reflecting on the work of Crowe et al. (2008) showed me I was not alone in my desire for students to perform at higher levels, that students should be expected to perform at a collegiate level by the end of their high school career, and many are currently lacking HOCS. A take-away for me was that I started to believe that I was able to apply many of the suggested application activities into my classroom, and I began to think about incorporating more HOCS activities by implementing what Crowe et al. (2008) outlined in the BBT. They suggested many activities that fall into the categories of Bloom's thinking levels, and thus acted as a guide to ensure that I was incorporating activities of critical thinking into my classroom. The BBT provided an organized chart illustrating the levels of Bloom's Taxonomy by providing key skills, examples of questions, types of questions, and characteristics of each type of question within that

level. It also outlined individual and group activities that can be implemented for addressing each level of Blooms.

An additional article that provided me with direction for my study was by authors Barnett and Francis (2012), who used a pre- and post-test design that I found myself implementing for my AR. As part of their assessment, they used a *Watson-Glaser Critical Thinking Appraisal (short form)* that I had never heard of, but after reading, I reflected on how to use it within my AR. It appeared this appraisal would have been a very helpful tool for me to administer before, and then again after, I introduced Bloom's Taxonomy to assess student critical thinking levels, and to assess whether critical thinking skills improved. Barnett and Francis (2012), following my review, utilized a secure Pearson test with a cost, however, in my search to find a pre- and post-test, I was also pointed in the direction of the Lawson Scientific Reasoning Test developed by Anton E. Lawson of Arizona State University. My search within relevant literature brought to light more resources, and brought me closer to developing a critical thinking assessment I would use in my AR.

Barnett and Francis (2012) additionally used multiple choice and essay tests to assess learning. Although in my research I only assessed scientific reasoning through a multiple-choice assessment, I do feel that in the future using multiple items to measure learning such as essay responses, would require students to demonstrate their knowledge in these two forms. Preparation for this in freshman biology is critical. I think that being able to dissect and understand these types of questions will be a skill students can take with them into their higher education. In addition, Barnett and Francis (2012) reported a

description of each test question, and then the pre-and post-test score, and I saw my data analysis and reporting taking a similar quantitative form, but where the approach of Barnett and Francis (2012) presented mean scores and the standard deviations, given that my data would be a smaller sample size, I represented each individual pre-and post-scores.

I found again during my literature review that I was not alone in hoping to improve student critical thinking skills. For example, authors Thomas Lord and Sandhya Baviskar (2007) stated many facts that agreed with my AR. They argued that many college graduates are underprepared and graduate without the ability to apply the information that they supposedly learned. The article recognized that currently science is taught in a very detailed manner, and when assessed, students simply needed to regurgitate facts, not truly apply the information, and thus show higher processes. A gap is emerging where our education system is creating students that have a growing number of misconceptions. "As such, students concentrate their studies on terms and definitions, spending little time on application and analysis. To correct the problem, instructors are encouraged to formulate more questions around the mid and upper levels of Bloom 's taxonomy in the examinations they prepare" (Lord, T. & Baviskar, S., 2007, p. 40).

Lord and Baviskar (2007) addressed a concern that I had on student learning and abilities, that students were currently getting to higher levels of their education, but were unable to critically think about the information that they have learned. This article provided many figures that sketched out ideas of Bloom's Taxonomy. The article also quantified how often questions appear from each of Bloom's levels on college exams. I

was disappointed but not surprised that the very first level of Bloom's Taxonomy, knowledge, comprises 50% of exam questions, with the second level, comprehension, making up about 20% more of the questions. I used this information to help guide my students to attempt questions that focus on high level reasoning, i.e. application, analysis, synthesis, and evaluation. I was left with this take away: "Developing questions based on Bloom's hierarchy would be a productive way of reversing the trend of graduating college students with a large number of misunderstandings in the courses they have taken" (Lord, T. & Baviskar, S., 2007, p. 44). This gave me guidance that I should push students to write and identify numerous questions that follow Bloom's hierarchy, I believed from this the students needed to be exposed to understanding Bloom's Taxonomy, which I incorporated into my AR as part of my treatment.

A peer-reviewed article that caught my attention is a research project that was conducted by Christie Chin (2007). Chin took the approach very similar to an action research that worked to inspire my action research approach. She found six willing teachers of the same grade of science (7^{th} grade) from four different schools to participate in her study. Each teacher taught thirty-six lessons to large classes (about 40 students per class) that were audio taped. Each teacher followed a national science curriculum, and specific attention was paid to questioning and productive student thinking. As a conclusion, the researchers stated that this study continues to reinforce the idea that the dialogue that occurs between students and teachers in the classroom contributes to overall student understanding of the science topics.

From Chin (2007), I made many connections to my action research, first a

traditional versus constructivist/inquiry model of questioning could be applied to my AR, as I wanted to move toward more inquiry-based teaching and learning which have an emphasis on critical thinking skills. I gained a clear picture other researchers would set-up, carry out, and analyze the data collected. This investigation (i.e., Chin, 2007) as mentioned earlier, I found to be a model of a somewhat extensive action research. I also found the way the researcher displayed and discussed her data particularly helpful. For example, she included many charts that would be helpful in my AR, such as one that outlined the teacher questioning approaches. Chin (2007) also included many student and teacher discussions that could be used as evidence for qualitative data that I enjoyed reading through and used as a model format in my AR.

I found myself following closely the methods used in research set-up and data collection found in the article by Nichols, K., Burgh, G., & Kennedy, C. (2017). Again, although this study is much larger than any I could conduct, the methodologies were helpful, and I found myself conducting and following out the data collection approach on a much smaller scale. The study by Nichols et al. (2017) involved 227 students, 18 teachers, and 9 primary schools, and followed students over a two-year grade sequence. The study recorded, transcribed, and coded for questioning and inquiry behaviors that students displayed. This is what caught my attention about this research article. Teachers used the 5E instructional model to teach inquiry-based science units, then used videotaping to record actions of students during small group activities, from these recordings the student discourse was then coded and analyzed into five behaviors: did they ask procedural questions, did they ask substantive questions, and did they display

recall cognitive engagement, compression engagement, or higher-level thinking? I took away from this article the idea to have the students go back and reflect on their level of questioning and engagement as part of the data collection and lessons encouraging and being mindful of Bloom's Taxonomy. This would become a very formative experience for many high school students. Additionally, this article presented both qualitative data (in the form of student quotes organized by the coded categories), and quantitative data (showing the students change over time in each the categories of questioning and behavior accessed) in a way that I modeled in my AR.

Finally, I reviewed two articles that discuss two different ways in which researchers chose to incorporate critical thinking and Bloom's hierarchy into the classroom. The first study conducted by Chamberlain et al. (2004) focused on research around short answer questions and using these to improve higher-order thinking. The second by authors Kragten et al. (2012) investigated student success with diagramming tasks in secondary science. Both articles discuss ways in which levels of Bloom's Taxonomy can manifest in the biology classroom. Both articles also shared ways in which answers can be expressed in and engaged at using a higher level of Blooms, for example, understanding and explaining requires short answer response, and also looking at and interpreting diagrams.

In the Chamberlain et al. 2004 study, *The Role of Short Answer Questions in Developing Higher Order Thinking*, the authors demonstrated that higher levels of thinking were needed to be engaged in short answer questions. It suggested that this writing skill must be scaffolded and sequenced. From my preliminary student interviews,

I knew that question asking or answering had not been directly taught to our students, so I needed to explicitly teach and scaffold this as supported in the literature. This article also suggested the complexity and role that language plays in understanding higher levels of thinking, illustrating the need for guiding questions from lower order questions transitioning to higher levels. I was thinking that language and discussion plays a huge role in acquisition and application of Blooms to encourage questioning, but then, after reading the article, I was certain I needed to address discussion to further progression; and thus building the levels of questions over the course of a few weeks for my students to increase understanding and comprehension.

Next, the second article, *Diagrammatic Literacy in Secondary Science Education* by Kragten et al. (2013), states that diagrams learning tools can help with the mental models and clarify abstract ideas. Diagramming also taps into the student's spatial skills. In biology, these skills are needed to understand many course topic objectives that are too small to see what is happening such as protein synthesis, immunology, photosynthesis, cellular respiration, and organic compounds. Kragten et al. (2013) also stated that again students are not explicitly trained in interpreting diagrams. In their research, they have come up with a training program, including these steps: "1. Include strategies for encoding diagrams with unfamiliar components, 2. Focus on the interpretation of abstract diagrams, and 3. Facilitate students in learning how to gain a deeper understanding of diagrams that contain new information" (Kragten, M., Admiraal, W., & Rijlaarsdam, G. 2013, p. 1798). I feel this direction helped me to know what and how to explicitly teach students a task to access those higher order questions again in my lessons and reminded

me to explicitly and directly teach students these skills, then proceed to apply the skills, and finally test to see if improvement occurs.

In summary, increasing student's higher order cognitive skills is a common thread that many educators seek. Using Bloom's framework and incorporating lessons that use inquiry methods and asking driving questions regularly will work to advance student's engagement and higher order thinking application. There are additionally many larger studies that guided and sparked ideas for my methodology and implementation.

METHODOLOGY

This study involved the direct teaching and application of Bloom's Taxonomy and levels of questioning over a treatment period of about six weeks. It was carried out in my three sections of freshman biology at Telluride High School during the spring of the 2017-2018 school year in an attempt to help increase critical thinking skills and student confidence while preforming higher order cognitive skills. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A). The research methods were performed in accordance with established and commonly accepted educational practices involving normal educational settings.

There were all categories of student enrolled in freshman biology, or biology I, at Telluride High School because it is a graduation requirement. In the class (N=61), about 16% were Latino/a, 15% were students with IEPs or 504 accommodations, and about 27% of the freshman class was new to our school and district for the 2017-2018 school

year. This is fairly typical to see in our school, as many families make the move to Telluride (a resort town) for their children to finish their high school career. Also, within my data collection cohort, 6% were sophomores that were re-taking the course. Finally, school-wide, about 25% are typically eligible for free or reduced lunch, and my sample included approximately 50% male and female enrollment.

I conducted a "within" research design. I focused on a descriptive study where all 61 biology students were followed throughout a six-week treatment period. In all my biology classes I taught Bloom's Taxonomy referencing a Bloom's Questioning Sheet (Appendix B). The data collection began in late February of 2018 and ended in early April of 2018. During the treatment timeframe of about six weeks (three units of subject material) students received direct instruction on Bloom's Taxonomy levels and worked to identify the level of Blooms in classroom activities. The units that were utilized during the six-week treatment period included the topics of DNA and Protein Synthesis, Genetics, and Taxonomy.

My first lesson that introduced Bloom's Taxonomy was inspired by an activity I saw in the AVID (Advancement Via Individual Determination) lesson plans, which involved having students take a daily item, such as bubble gum, and then directing the students to start exploring the item by asking a knowledge question about their object, then build on that going deeper by asking questions from all categories of Blooms. This activity made them experience the levels of engagement with Blooms. Once they had a concrete example of Bloom's levels, I had them apply the questions to items that we did in class. For example, they had to ask questions on their note sheets or when we watched

a clip from a TED talk. At the end of a class, they had to generate questions from the activities in our daily discussions and place them into the levels of Blooms. I would have partners "turn and talk" about their questions or have students share out to the full class what they were questioning following the lesson. I recorded my observations to monitor potential changes over time in attitude, engagement, or other standout moments. The final activity I incorporated into my classroom during this time frame was requiring a "mini-research" write-up on a topic of their choice related to the materials that we have covered in the unit that they would like to know more about. Once they decided on a topic they were to then brainstorm, write out, and find the answers to what they had asked. During this research, they were required to ask and attempt to answer at least one question from each of Bloom's levels. Following their independent research, we then held a class discussion to share out at least one interesting question they asked and the answer they found.

I required students to ask at least two questions in their unit notes, inspired by the AVID Program, and the concepts of Cornell Notes our school has adopted. The idea behind Cornell Notes is to have multiple "visits" back to your notes, during these "visits" students mark the text, summarize the text, and generate questions they might have about the information, or beyond the information, or also make predictions about test questions that could be about the focal information (Appendix C). Next, as we watched a quick video clip or TED talk I was able to ask for question reflections. My idea behind this is that instead of summarizing or documenting the information they just heard, I had them generate three questions that the video clip inspired. I administered a pre- and post-

critical thinking test, Lawson's Classroom Test of Scientific Reasoning (Appendix D), a pre-treatment, middle-treatment and post-treatment Likert confidence survey (Appendix E, Appendix F, Appendix G), and engaged students in group interviews pre-treatment and post-treatment (Appendix H, Appendix I). Furthermore, throughout the treatment period, I tried to be more aware of encouraging student discussions around questioning building in time to "turn and talk" to a partner about what questions you wrote for your notes, or "share out" your questions. This information on meaningful prompts and student engagement was recorded in my teacher progress journal. Currently, Table 1 below outlines the data collection methods that I used to analyze each sub-question.

Table 1.
Data Triangulation Matrix and Research Methods for My AR

	Data Collection and Research Methods				
	Student Interviews (small group)	Student Likert surveys	Student developed asking/answering questions	Critical Thinking Pre-/Post-test	Teacher progress journaling
Main AR Question: Does explicitly teaching Bloom's taxonomy and providing direct student practice increase student success on higher-order questions?					
Sub-Question #1: What foundational skills do students need to complete higher order thinking questions successfully?					
	X		X		X
Sub-Question #2: What activities can be used to teach higher-order thinking questions effectively?					
	X		X	X	
Sub-Question #3: Do student test scores increase with exposure to teaching question decoding and Bloom's Taxonomy?					
			X	X	X
Sub-Question #4: Do student confidence levels increase with question exposure and decoding practice?					
	X	X	X		X

My treatment tools were aided in validity and reliability through numerous checkpoints. My pre-treatment interview questions were piloted and refined last year

during the spring of 2017 as I was brainstorming this AR project through my peers in my Educational Science course. From the pre-treatment questions, I developed my post-treatment questions to further my understanding and connection to my students on this topic. My Likert survey questions were peer-reviewed and feedback was generated by my team of Derek Engebretsen and Katrina Cornell to ensure authenticity and trustworthiness. Finally, the Lawson Classroom Test of Scientific Reasoning has received many acknowledgements as a published instrument, highly respected in the science modeling community.

DATA ANALYSIS

As the pre- and post-data trickled in during the six-week treatment period, I was able to identify patterns and categories that presented a meaningful message, with the exposure to and practice of asking questions according to Bloom's Taxonomy and finding answers, student critical thinking scores increased and more upper levels of questions according to Bloom's Taxonomy were being asked by students. Using the Lawson Classroom Test of Scientific Reasoning (CTSR), I was able to obtain a pre-treatment test score and a post-treatment test score. My initial results indicated that the CTSR scores of the students increased over the six-week treatment period (Figure 1).

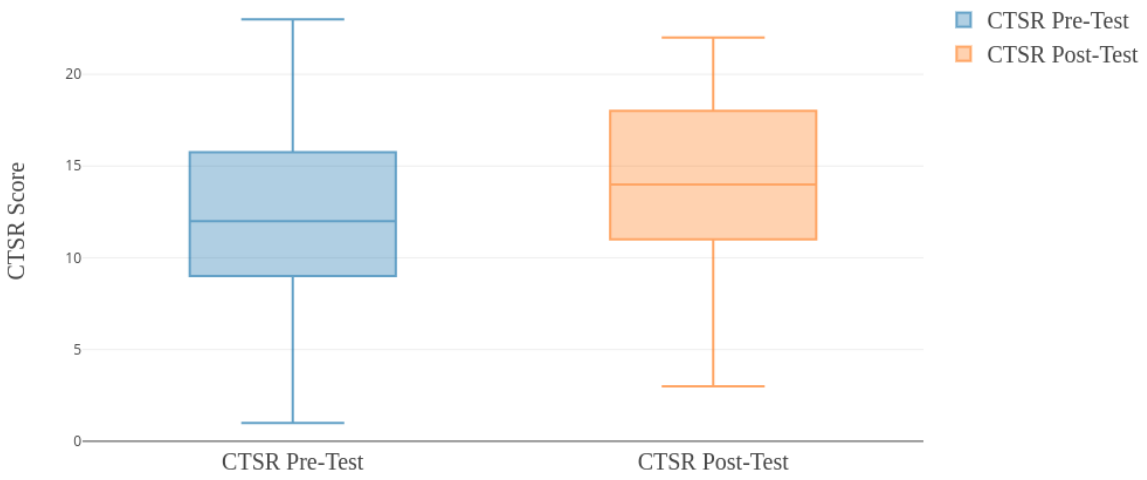


Figure 1. Score distributions of pre- and post- CTSR test scores, *(N*=61).

For example, the box and whisker plots show pre- and post-treatment test results, and throughout the treatment the mean scores and lowest outliers have increased. The mean score for the pre-test was 12.07 while the mean score for the post-test was 13.87. The standard deviation for the pre-test was 4.7 while in the post-test it was 4.91. After running a matched paired T-test with the pre- and post-test data, the p-value was found to be much less than $p<0.000$, indicating that it was very unlikely that the increase in the post-test scores was due to chance. The student that posted the highest CTSR outlier score in both tests was a student that had an ALP or Advanced Learning Plan. The student who posted the lowest score was a NEP ELL, i.e., a Non-English Proficient English Language Learner.

Next, my results from the student Likert questions from a pre- and post-treatment survey yielded results that suggest that pre- and post-treatment, student attitudes towards school, grades they earn, and how challenging they feel their class content materials are remaining mostly unchanged (Figure 2). Following the treatment period, 93% of students

reported that they now know what Bloom's Taxonomy is. Pre-treatment, 46% of students reported that they did not know what Bloom's taxonomy was. Finally, when asked, *I often challenge myself to think deeper about a problem*, 85% of students reported that they agree or strongly agree with this statement compared to 57% of students who agreed with this statement pre-treatment.

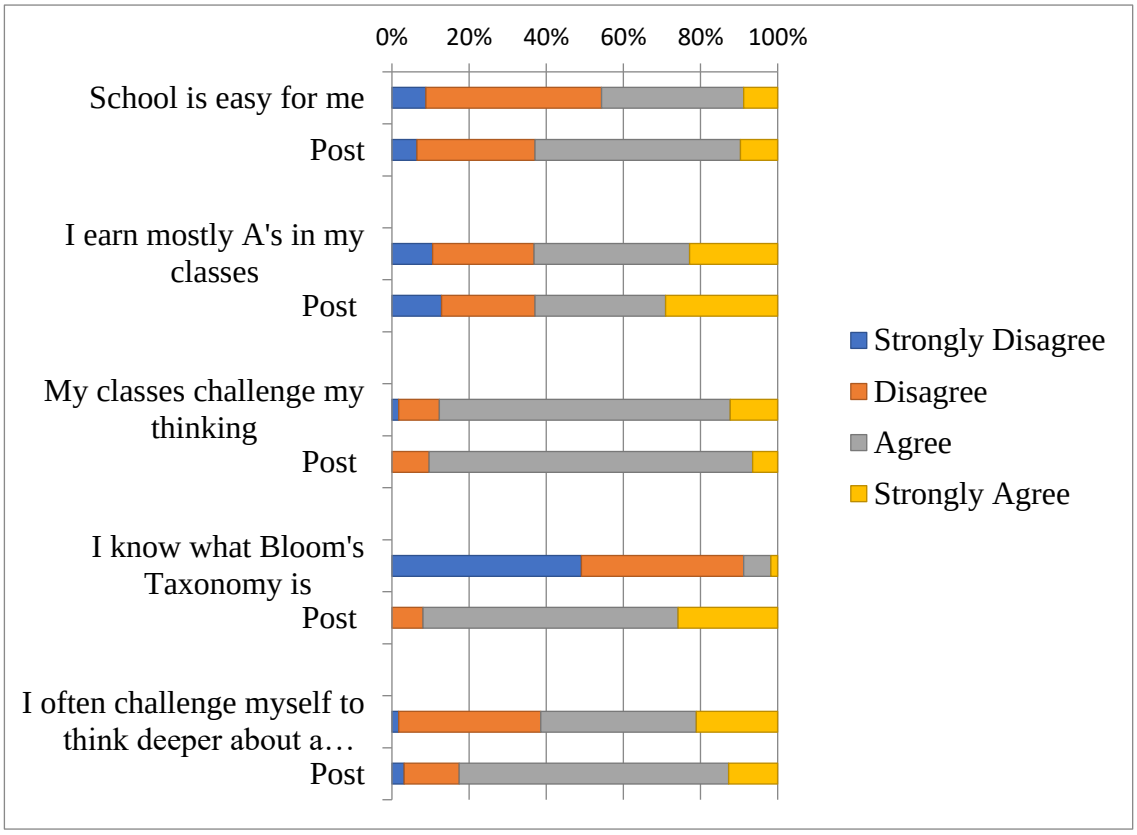


Figure 2. Data results of student Likert survey pre- and post-treatment, (*N*=61).

During the pre-treatment interviews most students reported that they could not explain to me what Bloom's Taxonomy was. A few students during these interviews revealed that they have "heard of leveled questions but could not define or give an example." Following the treatment and exposure to Bloom's Taxonomy during the student interviews, almost all students reported that they understood the concept of

Bloom's Taxonomy. When asked to describe Bloom's Taxonomy in their own words students stated, "Bloom's Taxonomy is a way to gain information by asking different questions," and "it is a way of solving open-ended problems by using an order of different levels of questions; the further you go in your questioning, the deeper the information gets transitioning from general ideas to real world applications."

Anecdotally, I recorded in my reflective journal on 4/5/2018, that "during the post-interviews, students excitedly shared their own definitions for Bloom's Taxonomy, they were nodding their heads along with their peers as they made statements they agreed with." Furthermore, recorded in my reflective journal is an entry following our video reflection on 4/6/18, "after students watched a clip (18 minutes from what 'Darwin Never Knew') I had them turn and talk with their partners sharing the questions they had recorded. I am pleased to hear all pairs on task, sincerely sharing what they questioned from the film, they were very academic-oriented conversations."

Since our school adopted the AVID program in 2015, we have been pushing toward implementing school-wide Cornell Notes, a strategy of note taking that has the author interact with their notes. There is a general trend from pre-treatment to post-treatment, it shows that students increased the amount of Bloom's questions in the application, analysis, synthesis, and evaluation levels (Figure 3).

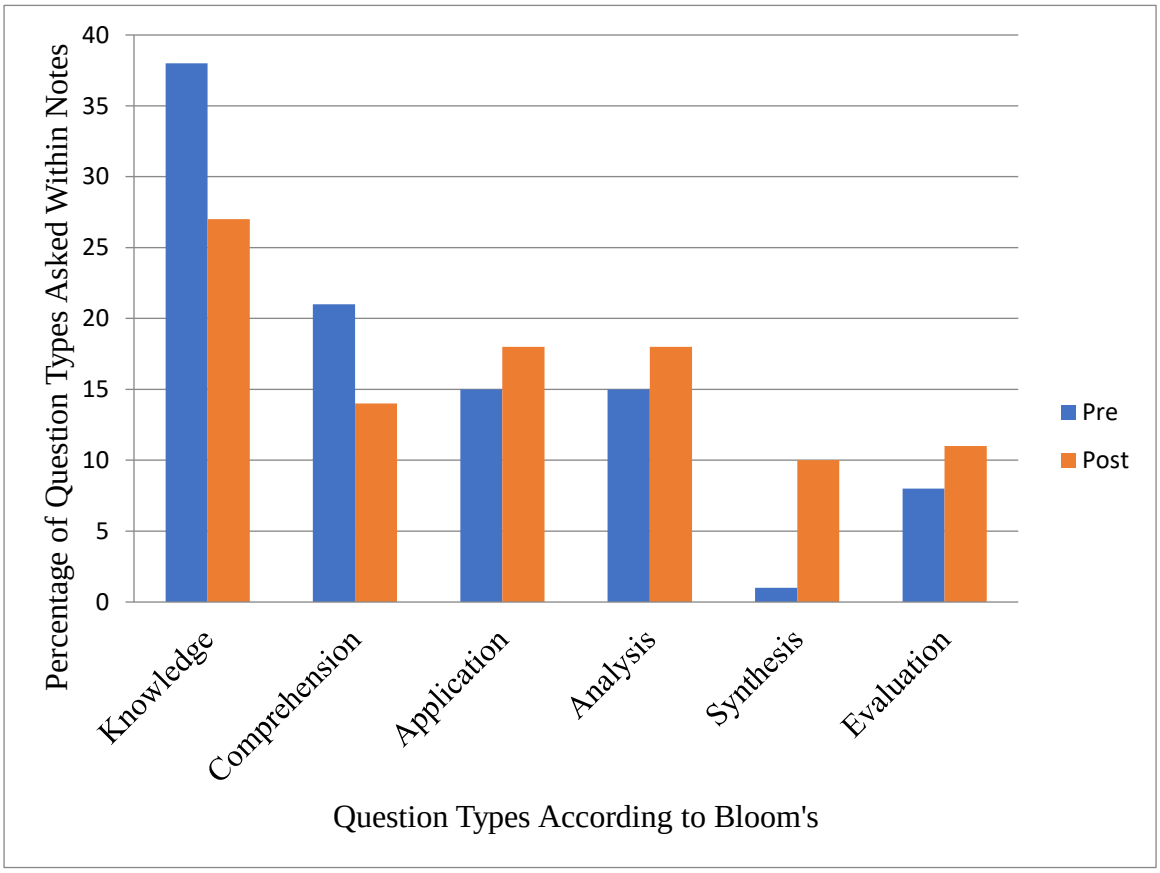


Figure 3. Question types asked according to Bloom's pre- and post-treatment within student notes, *(N*=61*)*.

During the mid-treatment Likert survey, it was asked, *is there a certain level that you find hardest to ask*? Students replied that synthesis and evaluation questions were the hardest to ask because, "you have to research it and really understand your topic to be able to back up your opinion or even know what to ask for those levels." Another student claimed, "they challenge you to make informed observations and actually critically think" in reference to the synthesis and evaluation levels. When asked, *what more do you feel you would need in order to help ask or answer these tough questions*, the student response that showed up the most from the surveys was, "more time." The theme of needing more time to feel a sense of mastery showed up in student interviews as well,

"we need time to ask questions," "I need time to process and soak in the information before going forward." Two students made separate suggestions of "using the last ten minutes to work so we could ask questions if we're confused."

Students were asked to record three questions as they had as they watched a TED talk (pre-) or video clip (post-), they then reported the type of question that they had written according to Blooms as they were listening to the information (Figure 4).

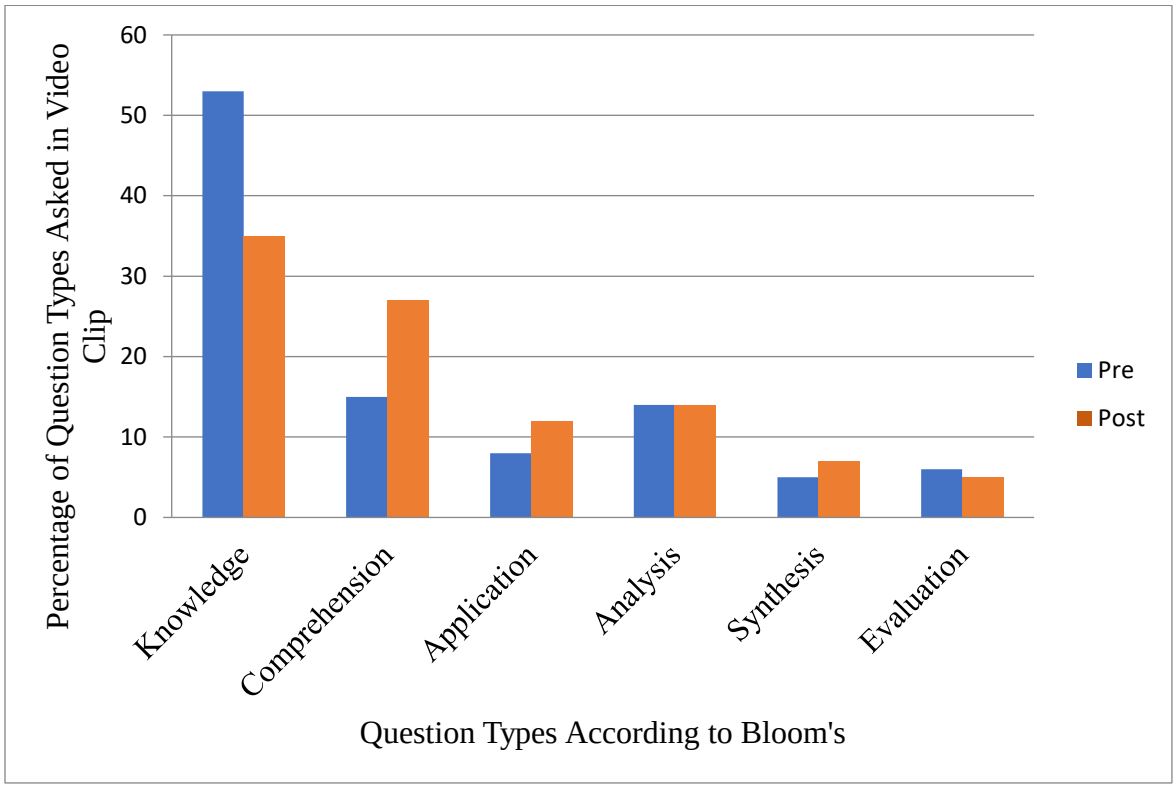


Figure 4. Question types asked according to Bloom's pre- and post-treatment from a video clip, *(N*=61*)*.

Of the questions reported from 61 students, pre- and post-treatment, there was a shift in the frequency of question types posed, moving from 53% of the pre-treatment questions being knowledge compared to the post-treatment questions that were more spread out throughout the Bloom's levels. Although knowledge questions were still the

most frequent type of question asked post treatment, only 35% of questions were in this category.

From the student Likert survey results, students reported their ability to ask and then answer their questions remained generally unchanged (Figure 5). During both pre- and post-treatment Likert surveys, 92% of students reported that they could ask questions according to Blooms and 87% responded that they were able to answer the questions that they posed. Over the course of the treatment more students found researching a topic with Blooms less interesting. "It's fun to find new knowledge," this student stated in response to agreeing their Blooms research was interesting. Another responds "I find it interesting because I get to choose the topic." Yet others responded they disagreed for reasons such as, "it is hard to do." In student interviews, it became apparent that students understood that they needed to ask and answer questions because, "it is a way you learn and can help other people learn," "so you can make connections," and "questions give you clarification and meaning, they help you realize what you do and do not know."

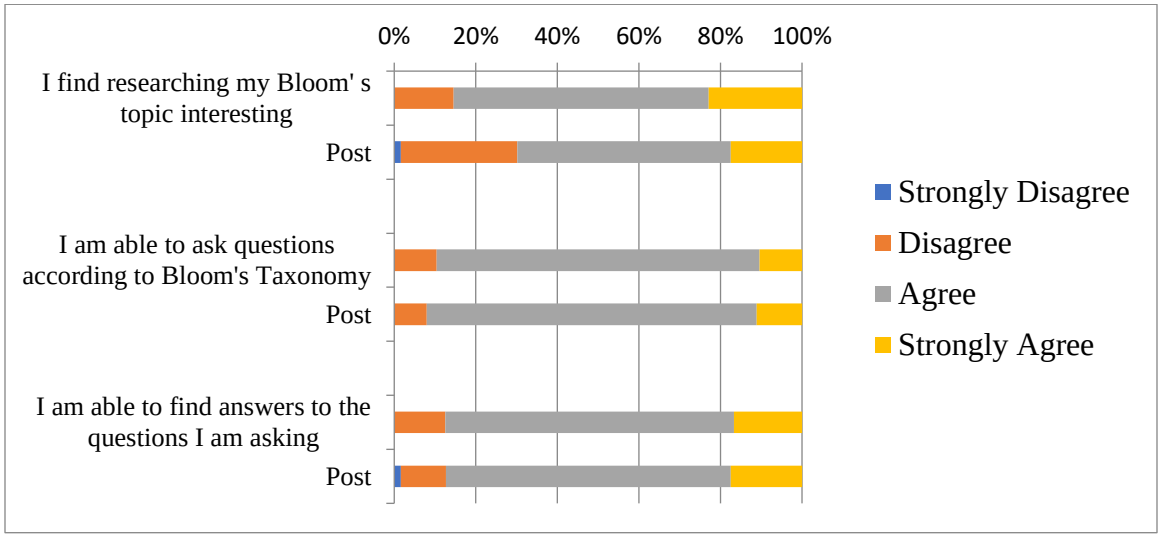


Figure 5. Student reported answers to Likert survey questions mid-treatment and post-treatment, (*N*=61).

There was little to no correlation between the student semester grade and the average question level that was posed pre-treatment (Figure 6). This graph was created using an average of all the question types that the student posed during both the pre-treatment video clip questioning and the Cornell notes questions compared with the student semester one grade they earned. The R^2 value was 0.0166 demonstrating that there was little to no correlation between the two variables pre-treatment.

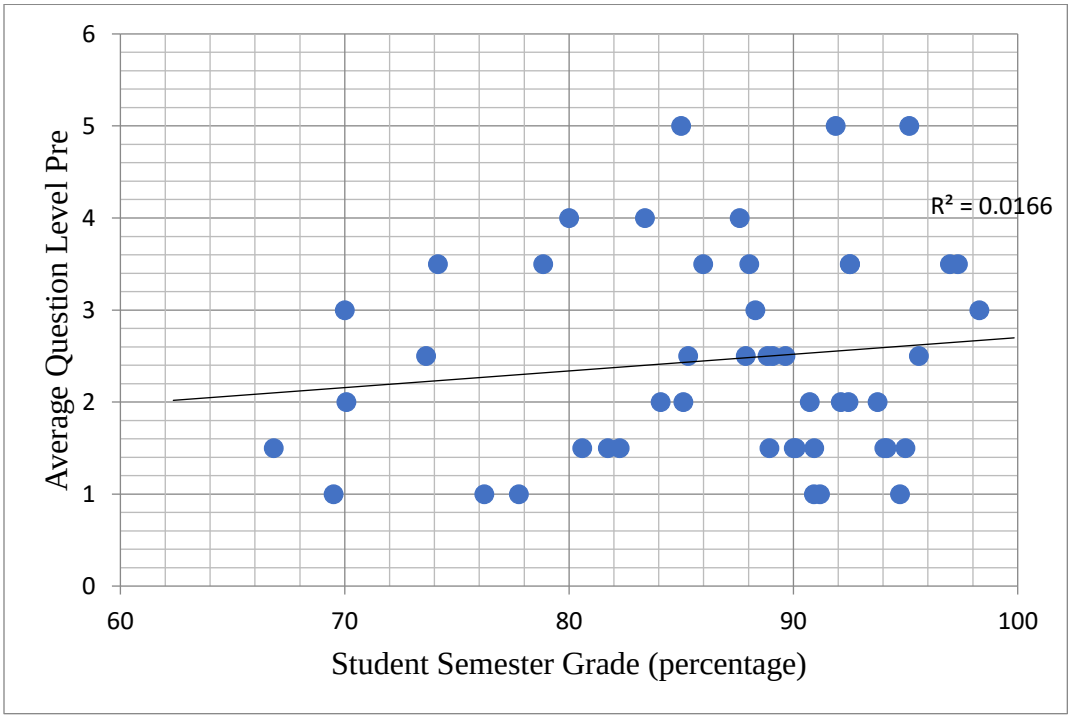


Figure 6. Student earned semester 1 grade versus the average question level posed in note and video activity pre-treatment, (*N*=61).

Compared to the pre-treatment graph, where there was little to no connection between the student earned semester grade and the average level of questions the student posed on the video and notes activities, post-treatment, there is an increased correlation between the grade the student earned at the semester and the average question level they were posing (Figure 7).

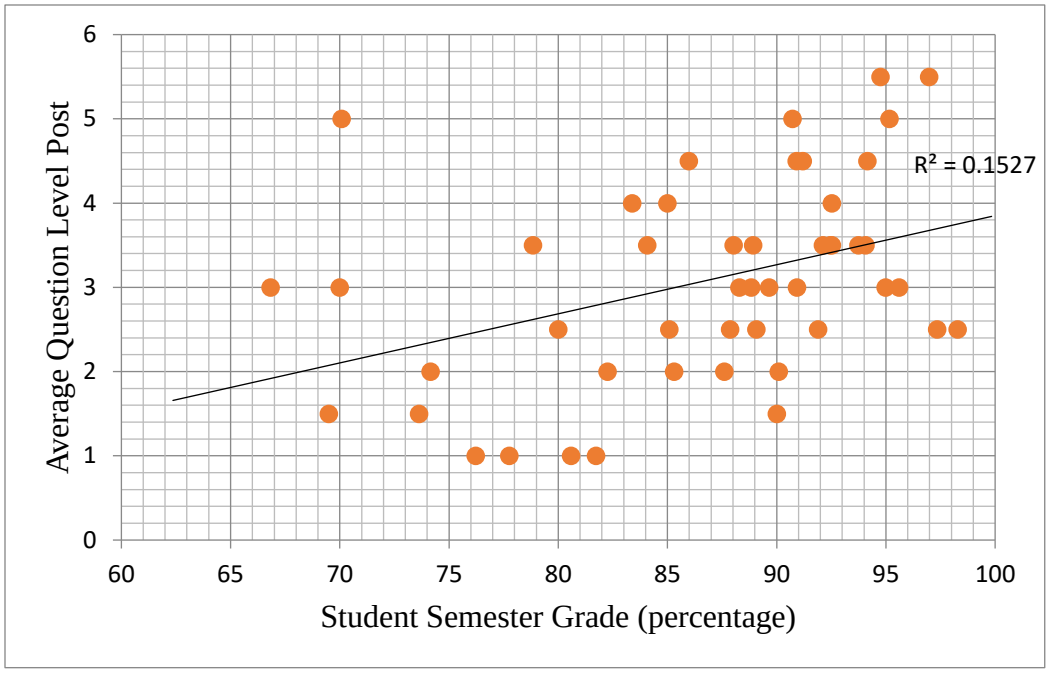


Figure 7. Student earned semester 1 grade versus the average question level posed in note and video activity post-treatment, (*N*=61).

The R^2 value was 0.15269 which illustrates there is more of a correlation between the student semester grade and the average question levels asked. The R^2 value increased pre- to post-treatment which illustrates that a greater correlation between the grade the student earned in the course and the levels of questions that the student asked. The connection between the student grade and increase in higher levels of questions asked was especially evident for the students in the highest range of the class. If I needed to speculate, students who earned A's and B's (80-100 percent) in class understand the course material and were able to apply their knowledge and wanted to look for ways to engage deeper with it, such as posing higher leveled questions. This is compared to students who were not grasping the course material and therefore earning a lower grade in the class C's, D's, and F's (65-80 percent). If you do not understand the basic

material, it is hard to pose upper level questions that dig deeper and beyond into the information.

From the post-treatment Likert survey, students reported that 78% agreed or strongly agreed that they felt the Bloom's Taxonomy structure was helpful to dig deeper into a topic, 22% felt that Bloom's Taxonomy did not help them gain a deeper understanding of a topic (Figure 8). Also included on the Likert survey was a question below to have student elaborate on their choice. Students who stated they would continue to use Blooms made statements such as they would continue to use this tool "to further understand my topic and make school easier."

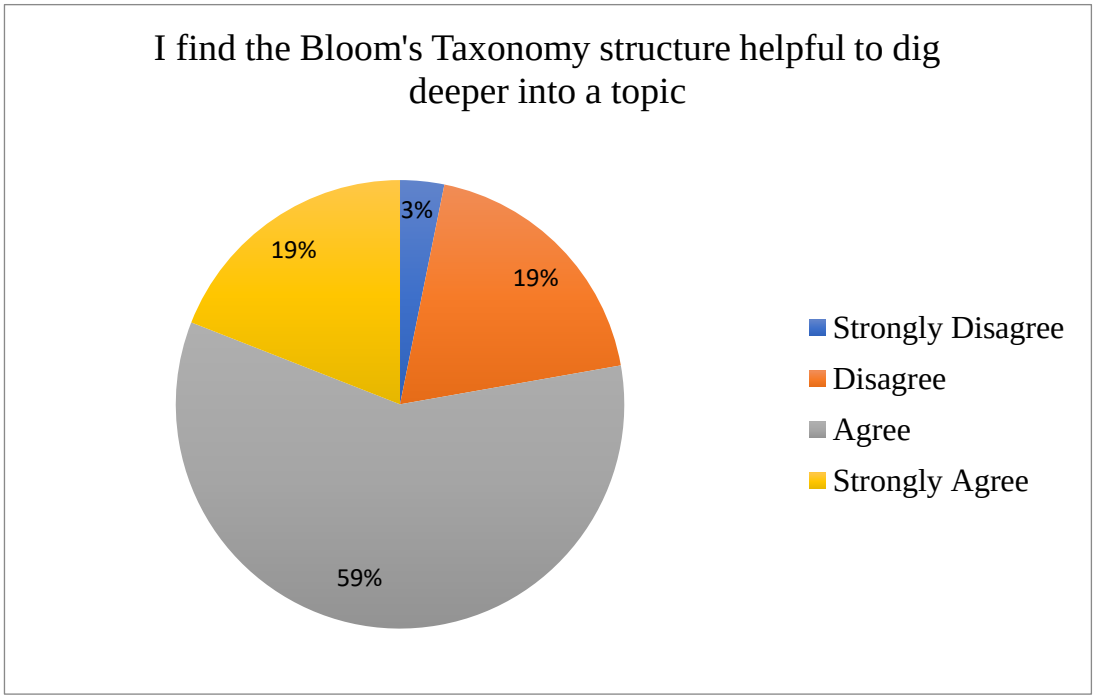


Figure 8. Student reported data from the post-treatment Likert survey question, *I find the Bloom's Taxonomy structure helpful to dig deeper into a topic*, (*N*=61).

In student interviews this data was further reinforced for example, as one student stated, “I was asking questions that I’ve never seen before or thought to ask, now I’m looking those up.” Another student stated that by doing the Blooms activities, “it gave me a deeper understanding of the topic because it forced me to use more ways to look deeper into a topic than I normally would do.” Yet another said, “you were pushed to ask questions, and by categorizing our questions, it made us think about exactly what we were asking and trying to find.”

On the post-treatment Likert survey, it was asked if students *will continue to use Bloom’s Taxonomy to challenge my thinking in the future*? Sixty-nine percent of students either agreed or strongly agreed that they would continue to use Blooms in their future while 31% of students reported that they would not use the structure (Figure 9).

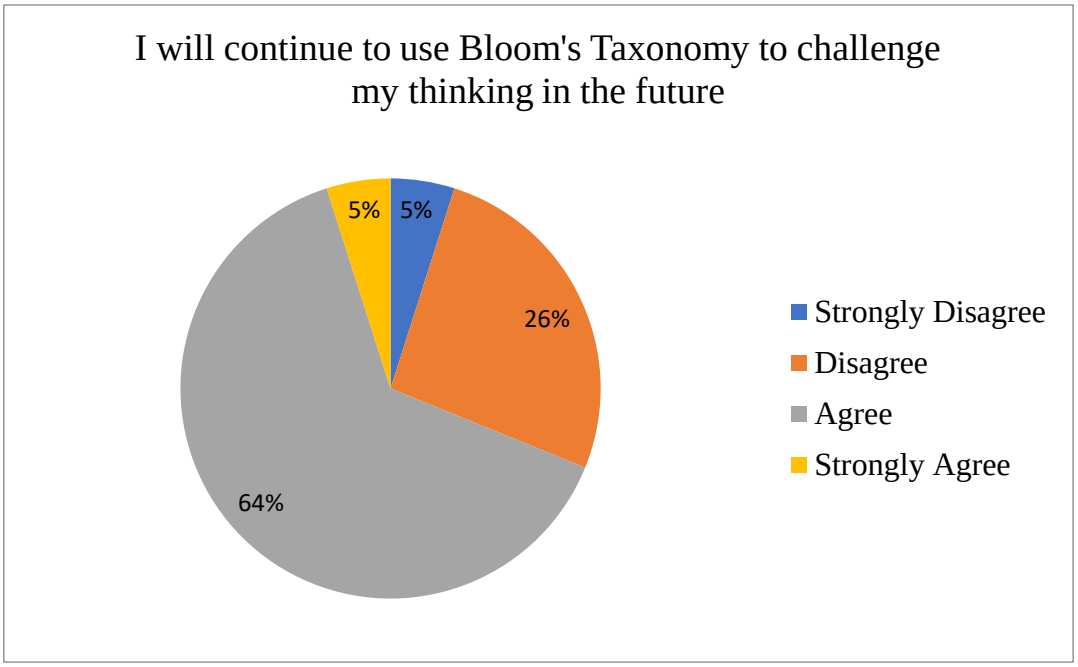


Figure 9. Student reported data from the post-treatment Likert survey question, *I will continue to use Bloom’s Taxonomy to challenge my thinking in the future*, (*N*=61).

When questioned in student interviews with a similar prompt, students responded with statements like, “now I have ways to think deeper about a topic.” When asked if students think they might use this in a different class, they responded with, “I might use it when researching a big question in history, but I feel like it doesn’t apply well in math.” In the interviews, it was a recurring theme that history and science are classes that make sense to use Bloom’s levels of questions in, but math might be difficult. From the Likert surveys responses around this topic included, “it’s a useful tool to dig into an unknown topic,” “it is a good research tactic,” or “it is a useful problem-solving method.” Many students however also felt that they would not continue to use Bloom’s Taxonomy for reasons such as, “I wouldn’t do it by choice,” “if I really need to learn more about a topic I will, but not for fun,” or “if I have to.”

INTERPRETATION AND CONCLUSION

The goal of this action research was to expose students to Bloom’s Taxonomy to increase abilities of students to ask and answer questions of all levels. This was done in hopes that critical thinking will be increased during this process and ultimately, students could feel comfortable and confident in asking and answering challenging questions that go above and beyond what is simply presented directly to them in class. From multiple data points, I feel that I can confidently conclude that utilizing Bloom’s questioning hierarchy in the classroom resulted with more students feeling comfortable asking and answering questions of all types and in doing so gained improved critical thinking skills.

I believe that high school is a great time to develop these skills as the literature states, most college students leave our education system lacking these higher order skills.

It became clear from *Biology in Bloom: Implementing Bloom's Taxonomy to Enhance Student Learning in Biology* by authors Crowe, Dirks, and Wenderworth (2008), that lower order cognitive skills (LOCS) or memorization and recall facts are being tested on most college exams, not higher order cognitive skills (HOCS). As a result, students are lacking these HOCS and a deeper understanding of the information.

However, as the Next Generation Science Standards (NGSS) continue to be implemented, and AP classes gain momentum, these questioning skills become critical for students to have now more than ever. The NGSS's very first science and engineering practice in fact states:

> Practice 1, Asking Questions and Defining Problems. Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations (NGSS Lead States, 2013, p. 4).

Additionally, outlined in the Advance Placement Biology Course Description are the science practices, the third practice of seven is, "The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course." Furthermore, the description states, "the student can pose scientific questions, the student can refine scientific questions, and the student can evaluate scientific questions" (https://apcentral.collegeboard.org/pdf/ap-biology-course-and-exam-description.pdf?course=ap-biology, p. 98). I feel that working to refine this skill of questioning in their freshman year can only help to open doors in their future and arm them with another means to access the information presented to them in their high school career and beyond.

As evidenced by the CTSR results, the Likert surveys, student interview

responses, and anecdotal qualitative observations recorded by me, their teacher, demonstrate student awareness of critical thinking increased. Students began to challenge themselves to ask questions that are simply beyond the knowledge levels according to Bloom. I feel that over the course of the six-weeks, the students pushed themselves to think a little differently about a topic and truly tried to expand their understanding by using a new tool, Bloom's hierarchy. The student questions generated and discussions surrounding our unit topics seemed to rise to a new cognitive level as students shared their findings from their research or revealed the questions they derived from their notes that took them beyond what we had simply discussed in class.

Students truly wanted to learn more, and I feel they were happy to be exposed to yet another critical thinking instrument for interacting with a topic. No student was able to define for me what Bloom's Taxonomy was pre-treatment, so exposure to a new way to address a problem was welcomed by these freshman students. With 69% of students reporting that they will continue to use Bloom's Taxonomy to challenge their thinking in the future, I think the students may not use every level, or memorize it, but I do think that they will remember how they can dig deeper into a topic and seek Bloom's hierarchy if needed.

As I have gathered in the results of all my research thus far, I have noticed the student questioning levels and cognitive abilities have improved. Since semester grades correlated to the average question levels that students were asking post-treatment, it still leaves the question, how do I help close the gap for my students who are not earning high grades, and wonder is it due to do a lack of application and connections of higher order

cognitive skills to the course material? This methodology works to help improve the student on average, but what can I do to help students make even more significant gains in higher order thinking skills, such as the students who were scoring below the standard deviation of the CTSR?

In conclusion, to answer my AR question, directly teaching Bloom's Taxonomy and providing students with practice and applications does increase critical thinking. This main AR focus was supported by student CTSR scores increasing (Figure 1), and average question levels increasing in note-taking and when watching and learning through visual media (Figures 3 and 4). In addition, students self-reported an increase in confidence with question asking and answering practice utilizing Bloom's Taxonomy (Figure 5 and 8).

One final note, I have found throughout my years of teaching that students enjoy and thrive with consistency. Since my AR was started and finished within the third quarter, we already had developed a class routine. By the end of my AR using language around questioning and Blooms became part of the routine, however, the students did not like the new addition at first. In the future, I believe that I will try to introduce Bloom's questioning early in the school year, such that I can maximize exposure and make routine the practice with questioning levels, question types, and incorporating them into activities.

VALUE

Through this research I believe I have begun to discover ways in which I can

encourage and develop higher order thinking skills in my classroom. From the literature, I have found that this is a question that many seek to help answer. Moreover, with careful and planned discussions and activities focused around question development, I now have hope that I can help students to continue to develop these higher order thinking skills in my classroom and that will help them in their future as university students or colleagues as they enter their careers and the workforce.

As I move forward, I hope that I can continue to create and implement helpful activities and ways to introduce higher order thinking skills such as questioning to encourage student learning. As I uncover more observations, student views, and disappointments or successes in my implementations I look to share this information with my colleagues beginning with my grade level team (9th grade), my PLC, my science team, and administrators. Since finding out about my research project, on two separate occasions, I have had the ELA teacher and the geometry teacher approach me and excitedly share information they had received from a conference they attended or a fellowship meeting that focused on questions. This shows me that others around me are excited and passionate about this subject and it begins a discussion. I am hopeful that the discussion has begun and with these teachers and together we can better our teaching, deepen student learning, and find common practices between educators within my school and beyond. With a common language and common tools those teachers willing to modify and update their teaching will grow and help their students grow. If things go well, I might try to present to my district science colleagues at a K-12 meeting that occur quarterly in our school. I think that critical thinking is not only a skill that can and

should be learned in a high school science class, but in all classes and grades. Maybe this can get the discussion going about school wide or district wide awareness of leveled questions and encouraging critical thinking and students can be exposed to ideas like Bloom's Taxonomy before their freshman year.

Furthermore, if I can gain participation and buy in of my students in a successful way, I believe together we can work towards a common goal of improving their critical thinking during their time in high school. It was very apparent that students have not had exposure to Bloom's Taxonomy or any formal introduction to questioning skills so we must apply them in their years to come. I truly hope some students from this cohort come back in their junior and senior years to take AP biology from me. Since AP biology is one of the classes where I really saw a struggle and deficit of higher order thinking skills, it would be extremely special to see where these students are in a year or two from now with their critical thinking. My students are a group I have informally shared my results with as they were a curious and supportive audience. They were dying to know the results that I found about them and pleased that they had made improvements and progress in their learning and questioning. I felt through sharing my ups and downs of my AR, they learned from my experience as I modeled something they might have to do in their not-so-distant future.

Finally, I have personally learned from and grew as an educator through the action research process. It has expanded my tools that I have as a teacher with the classroom assessment techniques and my confidence in conducting my own action research. I feel that this project has greater informed me on how to obtain useful and

guiding information from my students to help develop and drive best practices surrounding student learning. All things considered, it was fun; it was fun to be informed, it was fun to crunch the data and makes sense of the results, and it is fun to be in the classroom each day knowing that students are growing.

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APPENDICES

APPENDIX A

MONTANA STATE UNIVERSITY

INTERNATIONAL REVIEW BOARD

EXEMPTION DOCUMENT

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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Chair: Mark Quinn
406-994-4707
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Administrator:
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MEMORANDUM

TO: Katherine Twitchell and Walt Woolbaugh

FROM: Mark Quinn Mark Quinn CJ
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 14, 2017

RE: *"Does Explicitly Teaching Bloom's Taxonomy and Providing Direct student Practice Increase Student Success on Higher-Order Questions?"* [KT111417-EX]

The above research, described in your submission of November 14, 2017, 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:

_X_ (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.

_X_ (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

AVID HANDOUT OF BLOOM'S LEVELS OF THINKING: SCIENCE AND MATH

AVID Collaborative Study Groups – Student Handout

Before | During | After

Bloom's Level of Thinking: Science and Math

Name: _____ **Date:** _____

1. REMEMBERING— recalling information • What information is given? • What are you being asked to find? • What formula would you use in this problem? • What does _____ mean? • What is the formula for…? • List the…. • Name the…. • Where did…? • What is…? • Who was/were…? • When did…?	**2. UNDERSTANDING— explaining ideas, concepts, or information** • What are you being asked to find? • Explain the concept of…. • Give me an example of…. • Describe in your own words what _____ means. • To what (science or math) concepts does this problem connect? • Draw a diagram of…. • Illustrate how _____ works. • Explain how you calculate….	**3. APPLYING— using the information in a new situation** • What additional information is needed to solve this problem? • Can you see other relationships that will help you find this information? • How can you put your data in graphic form? • What occurs when…? • How would you change your procedures to get better? • Does it make sense to…?
4. ANALYZING— exploring and understanding relationships • Compare and contrast _____ to _____. • What was important about…? • Which errors most affected your results? • What were some sources of variability? • How do your conclusions support your hypothesis? • What prior research/formulas support your conclusions? • How else could you account for…?	**5. EVALUATING— justifying a stand or decision** • Predict what will happen to _____ as _____ is changed. • Describe the events that might occur if…. • How can you tell if your answer is reasonable? • What would happen to _____ if _____ (variable) were increased/decreased? • How would repeated trials affect your data? How significant is this experiment/formula to the subject that you're learning? • What type of evidence is most compelling to you? • Do you feel _____ experiment is ethical?	**6. CREATING— generating new ideas, products, or points of view** • Design a lab to show…. • Design a scenario for…. • Pretend that you are…. • Propose an alternative…. • Imagine what the world would be like if…. • Using a principle of (science or math), plan…. • Are your results biased? • How else would you…?

APPENDIX C

CORNELL NOTE REFLECTION AND BLOOM'S TAXONOMY

Cornell Notes and Bloom's Taxonomy Name:_____

Please complete the following reflection.

Note: This information is for my graduate school action research project and participation is voluntary. Choosing to participate or not to participate will not harm your grade or class standing.

Please select a Cornell notes from your binder before the date of February 15, 2018.

1. Which notes topic did you choose? _____
2. What is the date on those notes?_____
3. Using your Bloom's Taxonomy Sheet, please list below the types (levels) of questions you have asked:

Please select another Cornell notes from your binder after the date of April 6th, 2018.

1. Which notes topic did you choose? _____
2. What is the date on those notes?_____
3. Using your Bloom's Taxonomy Sheet, please list below the types (levels) of questions you have asked:

APPENDIX D

LAWSON'S CLASSROOM TEST OF SCIENTIFIC REASONING

CLASSROOM TEST OF

SCIENTIFIC REASONING

Multiple Choice Version

Directions to Students:

This is a test of your ability to apply aspects of scientific and mathematical reasoning to analyze a situation to make a prediction or solve a problem. Make a dark mark on the answer sheet for the best answer for each item. If you do not fully understand what is being asked in an item, please ask the test administrator for clarification.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

Revised Edition: August 2000 by Anton E. Lawson, Arizona State University. Based on: Lawson, A.E. 1978. Development and validation of the classroom test of formal reasoning. *Journal of Research in Science Teaching*, 15(1): 11-24.

1. Suppose you are given two clay balls of equal size and shape. The two clay balls also weigh the same. One ball is flattened into a pancake-shaped piece. *Which of these statements is correct?*

   a. The pancake-shaped piece weighs more than the ball
   b. The two pieces still weigh the same
   c. The ball weighs more than the pancake-shaped piece

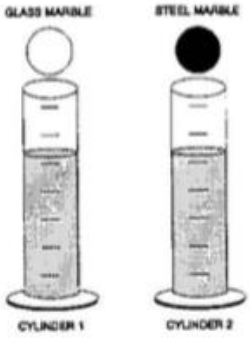
2. *because*

   a. the flattened piece covers a larger area.
   b. the ball pushes down more on one spot.
   c. when something is flattened it loses weight.
   d. clay has not been added or taken away.
   e. when something is flattened it gains weight.

3. To the right are drawings of two cylinders filled to the same level with water. The cylinders are identical in size and shape.

   Also shown at the right are two marbles, one glass and one steel. The marbles are the same size but the steel one is much heavier than the glass one.

   When the glass marble is put into Cylinder 1 it sinks to the bottom and the water level rises to the 6th mark. *If we put the steel marble into Cylinder 2, the water will rise*

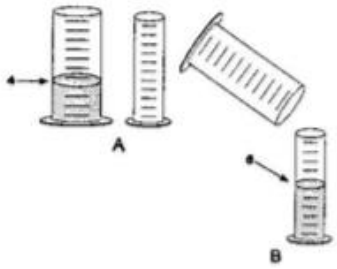


   a. to the same level as it did in Cylinder 1
   b. to a higher level than it did in Cylinder 1
   c. to a lower level than it did in Cylinder 1

4. *because*

   a. the steel marble will sink faster.
   b. the marbles are made of different materials.
   c. the steel marble is heavier than the glass marble.
   d. the glass marble creates less pressure.
   e. the marbles are the same size.

5. To the right are drawings of a wide and a narrow cylinder. The cylinders have equally spaced marks on them. Water is poured into the wide cylinder up to the 4th mark (see A). This water rises to the 6th mark when poured into the narrow cylinder (see B).



Both cylinders are emptied (not shown) and water is poured into the wide cylinder up to the 6th mark. *How high would this water rise if it were poured into the empty narrow cylinder?*

a. to about 8
b. to about 9
c. to about 10
d. to about 12
e. none of these answers is correct

6. *because*

a. the answer can not be determined with the information given.
b. it went up 2 more before, so it will go up 2 more again.
c. it goes up 3 in the narrow for every 2 in the wide.
d. the second cylinder is narrower.
e. one must actually pour the water and observe to find out.

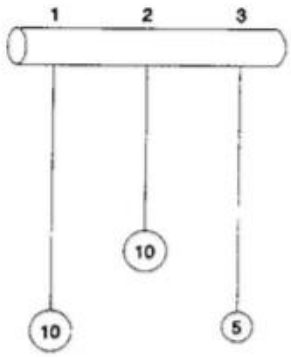
7. Water is now poured into the narrow cylinder (described in Item 5 above) up to the 11th mark. *How high would this water rise if it were poured into the empty wide cylinder?*

a. to about 7 1/2
b. to about 9
c. to about 8
d. to about 7 1/3
e. none of these answers is correct

8. *because*

a. the ratios must stay the same.
b. one must actually pour the water and observe to find out.
c. the answer can not be determined with the information given.
d. it was 2 less before so it will be 2 less again.
e. you subtract 2 from the wide for every 3 from the narrow.

9. At the right are drawings of three strings hanging from a bar. The three strings have metal weights attached to their ends. String 1 and String 3 are the same length. String 2 is shorter. A 10 unit weight is attached to the end of String 1. A 10 unit weight is also attached to the end of String 2. A 5 unit weight is attached to the end of String 3. The strings (and attached weights) can be swung back and forth and the time it takes to make a swing can be timed.



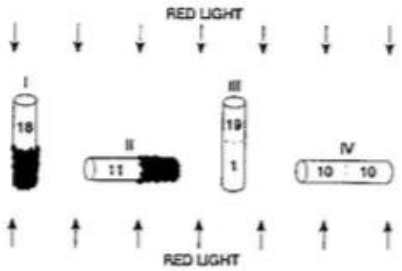
Suppose you want to find out whether the length of the string has an effect on the time it takes to swing back and forth. *Which strings would you use to find out?*

a. only one string
b. all three strings
c. 2 and 3
d. 1 and 3
e. 1 and 2

10. *because*

a. you must use the longest strings.
b. you must compare strings with both light and heavy weights.
c. only the lengths differ.
d. to make all possible comparisons.
e. the weights differ.

11. Twenty fruit flies are placed in each of four glass tubes. The tubes are sealed. Tubes I and II are partially covered with black paper; Tubes III and IV are not covered. The tubes are placed as shown. Then they are exposed to red light for five minutes. The number of flies in the uncovered part of each tube is shown in the drawing.



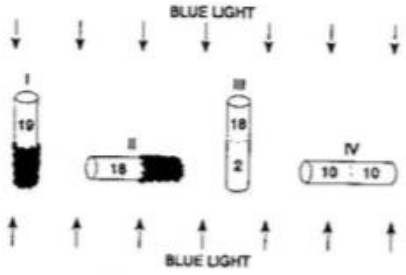
This experiment shows that flies respond to (respond means move to or away from):

a. red light but not gravity
b. gravity but not red light
c. both red light and gravity
d. neither red light nor gravity

12. *because*

a. most flies are in the upper end of Tube III but spread about evenly in Tube II.
b. most flies did not go to the bottom of Tubes I and III.
c. the flies need light to see and must fly against gravity.
d. the majority of flies are in the upper ends and in the lighted ends of the tubes.
e. some flies are in both ends of each tube.

13. In a second experiment, a different kind of fly and blue light was used. The results are shown in the drawing.



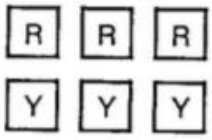
These data show that these flies respond to (respond means move to or away from):

a. blue light but not gravity
b. gravity but not blue light
c. both blue light and gravity
d. neither blue light nor gravity

14. *because*

a. some flies are in both ends of each tube.
b. the flies need light to see and must fly against gravity.
c. the flies are spread about evenly in Tube IV and in the upper end of Tube III.
d. most flies are in the lighted end of Tube II but do not go down in Tubes I and III.
e. most flies are in the upper end of Tube I and the lighted end of Tube II.

15. Six square pieces of wood are put into a cloth bag and mixed about. The six pieces are identical in size and shape, however, three pieces are red and three are yellow. Suppose someone reaches into the bag (without looking) and pulls out one piece. *What are the chances that the piece is red?*



a. 1 chance out of 6
b. 1 chance out of 3
c. 1 chance out of 2
d. 1 chance out of 1
e. cannot be determined

16. *because*

a. 3 out of 6 pieces are red.
b. there is no way to tell which piece will be picked.
c. only 1 piece of the 6 in the bag is picked.
d. all 6 pieces are identical in size and shape.
e. only 1 red piece can be picked out of the 3 red pieces.

17. Three red square pieces of wood, four yellow square pieces, and five blue square pieces are put into a cloth bag. Four red round pieces, two yellow round pieces, and three blue round pieces are also put into the bag. All the pieces are then mixed about. Suppose someone reaches into the bag (without looking and without feeling for a particular shape piece) and pulls out one piece.



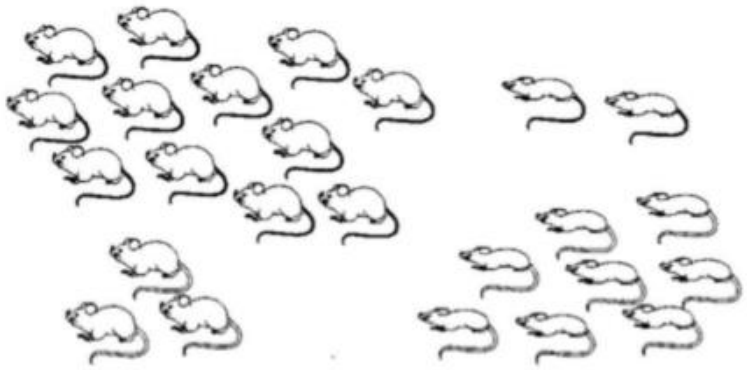
What are the chances that the piece is a red round or blue round piece?

a. cannot be determined
b. 1 chance out of 3
c. 1 chance out of 21
d. 15 chances out of 21
e. 1 chance out of 2

18. *because*

a. 1 of the 2 shapes is round.
b. 15 of the 21 pieces are red or blue.
c. there is no way to tell which piece will be picked.
d. only 1 of the 21 pieces is picked out of the bag.
e. 1 of every 3 pieces is a red or blue round piece.

19. Farmer Brown was observing the mice that live in his field. He discovered that all of them were either fat or thin. Also, all of them had either black tails or white tails. This made him wonder if there might be a link between the size of the mice and the color of their tails. So he captured all of the mice in one part of his field and observed them. Below are the mice that he captured.



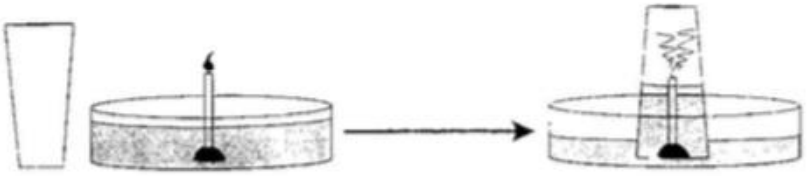
Do you think there is a link between the size of the mice and the color of their tails?

a. appears to be a link
b. appears not to be a link
c. cannot make a reasonable guess

20. *because*

a. there are some of each kind of mouse.
b. there may be a genetic link between mouse size and tail color.
c. there were not enough mice captured.
d. most of the fat mice have black tails while most of the thin mice have white tails.
e. as the mice grew fatter, their tails became darker.

21. The figure below at the left shows a drinking glass and a burning birthday candle stuck in a small piece of clay standing in a pan of water. When the glass is turned upside down, put over the candle, and placed in the water, the candle quickly goes out and water rushes up into the glass (as shown at the right).



This observation raises an interesting question: Why does the water rush up into the glass?

Here is a possible explanation. The flame converts oxygen into carbon dioxide. Because oxygen does not dissolve rapidly into water but carbon dioxide does, the newly formed carbon dioxide dissolves rapidly into the water, lowering the air pressure inside the glass.

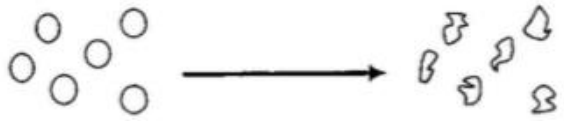
Suppose you have the materials mentioned above plus some matches and some dry ice (dry ice is frozen carbon dioxide). *Using some or all of the materials, how could you test this possible explanation?*

a. Saturate the water with carbon dioxide and redo the experiment noting the amount of water rise.
b. The water rises because oxygen is consumed, so redo the experiment in exactly the same way to show water rise due to oxygen loss.
c. Conduct a controlled experiment varying only the number of candles to see if that makes a difference.
d. Suction is responsible for the water rise, so put a balloon over the top of an open-ended cylinder and place the cylinder over the burning candle.
e. Redo the experiment, but make sure it is controlled by holding all independent variables constant; then measure the amount of water rise.

22. What result of your test (mentioned in #21 above) would show that your explanation is probably wrong?

a. The water rises the same as it did before.
b. The water rises less than it did before.
c. The balloon expands out.
d. The balloon is sucked in.

23. A student put a drop of blood on a microscope slide and then looked at the blood under a microscope. As you can see in the diagram below, the magnified red blood cells look like little round balls. After adding a few drops of salt water to the drop of blood, the student noticed that the cells appeared to become smaller.



Magnified Red Blood Cells After Adding Salt Water

This observation raises an interesting question: Why do the red blood cells appear smaller?

Here are two possible explanations: I. Salt ions (Na^+ and Cl^-) push on the cell membranes and make the cells appear smaller. II. Water molecules are attracted to the salt ions so the water molecules move out of the cells and leave the cells smaller.

To test these explanations, the student used some salt water, a very accurate weighing device, and some water-filled plastic bags, and assumed the plastic behaves just like red-blood-cell membranes. The experiment involved carefully weighing a water-filled bag, placing it in a salt solution for ten minutes and then reweighing the bag.

What result of the experiment would best show that explanation I is probably wrong?

a. the bag loses weight
b. the bag weighs the same
c. the bag appears smaller

24. *What result of the experiment would best show that explanation II is probably wrong?*

a. the bag loses weight
b. the bag weighs the same
c. the bag appears smaller

APPENDIX E

STUDENT LIKERT SURVEY PRE-TREATMENT

Name_____

Please complete the survey by reading each statement and circling how much you agree with the statement.

Note: This information is for my graduate school action research project and participation is voluntary. Choosing to participate or not to participate will not harm your grade or class standing.

1. School is easy for me.

   Strongly Disagree Disagree Agree Strongly Agree

2. I earn mostly A's in my classes.

   Strongly Disagree Disagree Agree Strongly Agree

3. My classes challenge my thinking.

   Strongly Disagree Disagree Agree Strongly Agree

4. I know what Bloom's Taxonomy is.

   Strongly Disagree Disagree Agree Strongly Agree

5. I often challenge myself to think deeper about a problem.

   Strongly Disagree Disagree Agree Strongly Agree

APPENDIX F

STUDENT LIKERT SURVEY MID-TREATMENT CHECKIN

Bloom's Check-in Survey Name:_____

Please complete the survey by reading each statement and circling how much you agree with the statement.

Note: This information is for my graduate school action research project and participation is voluntary. Choosing to participate or not to participate will not harm your grade or class standing.

1. I have discovered a better understanding of Bloom's Taxonomy over the last few weeks.

   Strongly Disagree Disagree Agree Strongly Agree

2. I find researching my Bloom's topics interesting.

   Strongly Disagree Disagree Agree Strongly Agree

3. Please explain your choice from question 2 above.

4. I am able to ask questions according to the levels of Bloom's Taxonomy.

   Strongly Disagree Disagree Agree Strongly Agree

5. Is there a certain level that you find hardest to ask? Why?

6. I am able to find answers to the questions I am asking.

   Strongly Disagree Disagree Agree Strongly Agree

7. Is there a certain level that you find the hardest to answer? Why?

8. What more do you feel you would need in order to help ask or answer these tough questions?

APPENDIX G

STUDENT LIKERT SURVEY POST-TREATMENT

Bloom's Post Survey Name:_____

Please complete the survey by reading each statement and circling how much you agree with the statement.

Note: This information is for my graduate school action research project and participation is voluntary. Choosing to participate or not to participate will not harm your grade or class standing.

1. School is easy for me.

   Strongly Disagree Disagree Agree Strongly Agree

2. I earn mostly A's in my classes.

   Strongly Disagree Disagree Agree Strongly Agree

3. My classes challenge my thinking.

   Strongly Disagree Disagree Agree Strongly Agree

4. I know what Bloom's Taxonomy is.

   Strongly Disagree Disagree Agree Strongly Agree

5. I often challenge myself to think deeper about a problem.

   Strongly Disagree Disagree Agree Strongly Agree

6. I find researching my Bloom's topics interesting.

   Strongly Disagree Disagree Agree Strongly Agree

7. Please explain your choice from question 6 above.

8. I find the Bloom's Taxonomy's structure helpful to dig deeper into a topic.

   Strongly Disagree Disagree Agree Strongly Agree

9. Explain your choice from question 8 above.

10. I am able to ask questions according to the levels of Bloom's Taxonomy.

    Strongly Disagree Disagree Agree Strongly Agree

11. I am able to find answers to the questions I am asking.

    Strongly Disagree Disagree Agree Strongly Agree

12. I will continue to use Bloom's Taxonomy to challenge my thinking in the future.

    Strongly Disagree Disagree Agree Strongly Agree

13. Explain your choice from question 12 above.

APPENDIX H

CRITICAL THINKING STUDENT INTERVIEW PROMPTS PRE-TREATMENT

Note: This information is for my graduate school action research project and participation is voluntary. Choosing to participate or not to participate will not harm your grade or class standing.

1. Can you tell me what you enjoy most about school? How about least? What activities are the easiest for you? Which are the hardest?

2. Do you know what Blooms Taxonomy is? Have you ever heard of leveled questions? If you have please describe what you know about them?

3. What type of instruction do you feel you've had in your previous years of schooling related to how to ask and answer questions? Can you give an example here that might help students understand, maybe try to describe the teacher, grade, or activities you can remember related to asking questions?

4. Do you feel more direct instruction would help? (Direct instruction is specific teaching; do you think that teaching specifically how to ask or answer certain types of questions would be helpful?)

5. Why do you think it is an important skill to be able to ask and answer questions? Why do you think that? Can you give me an example?

6. What is the toughest type of question to answer? Can you provide an example? Why do you feel it is the toughest?

7. What activity/skills do you wish you had to help you answer the questions? (Is there a certain way you think would be helpful to learn how to ask or answer questions?)

APPENDIX I

CRITICAL THINKING STUDENT INTERVIEW PROMPTS POST-TREATMENT

Note: This information is for my graduate school action research project and participation is voluntary. Choosing to participate or not to participate will not harm your grade or class standing.

1. Do you know what Blooms Taxonomy is? If you do please describe what you know about them?

2. Do you feel that doing the Bloom's activity has helped your understanding of Bloom's Taxonomy?

3. Do you feel that the Bloom's activity has helped to make you understanding of a topic deeper? Can you explain?

4. Does knowing about Bloom's Taxonomy effect the way you think about a task? In other words, has this strategy changed or helped your thinking process? Explain how it has changed or helped your thinking process?

5. Do you feel you will continue to use this structure on your own? Would you use this in another class?

6. Why do you think it is an important skill to be able to ask and answer questions? Why do you think that? Can you give me an example?

7. What is the toughest type of question to answer? Can you provide an example? Why do you feel it is the toughest?