

EFFECTS OF CRIB SHEETS COMPARED TO OPEN NOTEBOOKS ON  
SUMMATIVE ASSESSMENT IN AN INTRODUCTORY HIGH SCHOOL EARTH  
SCIENCE CLASS

by  
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July 2014

## DEDICATION

I am dedicating what this paper represents to my fellow sojourners, those who believe in the concept of lifelong learning, have a passion for self improvement, share their positivity and encouragement with others and somehow complete their goals amidst the day to day struggles that life tosses their way. May we never give up!

This paper represents the culmination of a journey that has been inspired by my colleagues, friends and students. I have grown so much through my experience of graduate classes and action research. I have been truly blessed!

I believe the greatest education we can give others isn't learning facts or procedures rather it is gaining the attitudes of positivity and perseverance.

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## ABSTRACT

My action research project compared the effects of using crib sheets or open science notebooks for student assessment scores. The results did not reveal a noteworthy difference. What I did find significant is students' perceptions that crib sheets are helpful, and I plan to utilize crib sheets next year.

My primary action research question was, "What are the effects of crib sheets compared with open notebooks on student assessment in an introductory high school earth science class?" A crib sheet, also known as a cheat sheet, is a student constructed paper that is used to provide help during an assessment.

Secondary questions investigated included: How do students perceive the usefulness of crib sheets? How do crib sheets impact student test anxiety? What are the effects of crib sheets compared to open notebooks on the length of time students spend on assessments? How do the results of my research affect me as a teacher?

My results mimicked what I found in my literature review. Overall my quantitative results did not support nor refute the use of crib sheets for improvement in assessment scores. Low student participation in constructing and using crib sheets contributed to the lack of conclusive results. However qualitative survey data did indicate that crib sheets could be helpful. The last survey showed that almost half of the students indicated they saw the value of crib sheets for improving their scores.

The greatest benefit for me in the immediate future is the direction that this project has given me for next year. I am convinced that the use of crib sheets can aid student learning and performance on assessments. To be successful I believe that students will need instruction in how to prepare a crib sheet.

I hadn't anticipated the concern that came to light through my research this past year. This issue is that student participation in learning activities is the lowest I have experienced in my eight years of teaching. I believe the greatest education we can give others isn't learning facts or procedures rather it is gaining the attitudes of positivity and perseverance.



## INTRODUCTION AND BACKGROUND

There is one teacher who each of us remembers. That one unforgettable teacher who motivated you to work harder and learn oodles of information about a subject you didn't like, perhaps history or, shudder, math! That teacher seemed to be in tune with what you as an individual needed in order to excel as a student. I believe that incredible teacher delivered just that, and each of us gained confidence by knowing them.

As a teacher I think we all want to be special. We love feeling a connection with our kids, but we want more than that. We want to help our students learn how to learn, and we want them to enjoy the experience of learning simply for learning's sake. Some of our students will go on to pursue college degrees and professional degrees. But many are only here for high school, here to grow in maturity and their ability to be responsible people.

I believe all teachers can improve our caring, coaching and curriculum delivery skills. I hoped to gain a greater understanding of my students' needs and advance my teaching skills by conducting action research in my class room. I expected to have results that I could use to make changes as an educator. With continued improvement I can lead my students to a growing appreciation for science as well as increase their knowledge of the world around them.

### Background

Columbia Falls High School is a four-year school in a small community in northwest Montana located near Glacier National Park. The enrollment in the high school is about 692 students in 2012-13, the most recent year for published statistics. Special education students comprise almost 11% of students and low-income students are over

56%. There was an increase from 49% low-income students in 2011-12. Our students are almost all Caucasian though there was no specific data on the district web site to quote exact figures of ethnicity. Our graduation rate as calculated by the state is 86.3% for 2012 (School District 6, *State of the District Report*). This is not an accurate reflection of the graduation rate because it is calculated by excluding fifth year seniors.

This year I taught three sections of earth science to sophomores. Earth science is one of two required science classes for most students with the exception of our top students, of which about three percent opt out and take chemistry. My science classes consist of all levels of students from individuals who enjoy science and want to learn more about it to special education students with Individual Education Plans and disinterested students. I have approximately five percent juniors who have failed the class in a previous year.

The class was formerly called integrated science. The curriculum has traditional earth science topics of geology, meteorology, oceanography and astronomy. There is also an emphasis on metrics and rudimentary mathematics used in science, as well as introductory units on chemistry and if time, physics.

One bias I have become more aware of is that I, like many teachers, was a fairly successful student. I have been adjusting my thinking and emotional responses to relate to the needs of my characteristic student rather than my perceptions of what education should be like. Who was my typical student at Columbia Falls High School?

Period four was very small class of only nine students. It gained one student and lost three, so as the school year progressed there were only seven students. Five of these students professed to care about their grade. This may be partially attributed to a desire to

remain eligible to participate in extracurricular activities which involved most of them. This group did perform better than the other two earth science classes, whether due to their disposition and effort, or the smaller class size. From this small class, three students, 33%, earned an A grade for the first quarter of 2013-14. This class is held right before the lunch break. Period four had six females and one male at year's end.

Period six was larger with a student population of 20. It was typically noisier, with more outgoing students, and they tended to get off task more often. Two students (9.5%) earned an A grade for the first quarter of 2013-14. It was in the mid-afternoon, with one class before it and one after. Period six had seven females and thirteen males, with six special education students.

The majority of my students had not performed up to my expectations on summative assessments. They seemed to have a 'disconnect' between the day-to-day learning activities and their ability to demonstrate mastery during assessments. Improvement on test scores would reflect an increase in knowledge and applications of the material studied, and demonstrate that students made progress in their test taking skills.

I began my action research journey with the goal of improving student understanding of earth science. I investigated whether students performed better on summative assessments when they were allowed to use crib sheets or when using open science notebooks. Evidence of increased understanding would be individual student improvement of assessment scores.

Improvement in testing is an area where students enjoy immediate benefits. Teachers are responsible for a community of learners. When assessment scores increase,

it affects our local educational climate. The students, parents, administration, teachers and the school district are positively impacted.

I believe that I need to continually improve my classroom influence and effectiveness. This is an ongoing work in progress, one in which I am constantly reflecting and responding to. My processes for this include rewriting labs to include more critical thinking questions, redoing student notes to include more student inter-activity and updating PowerPoints so they are more engaging for students. While these endeavors are important and will continue, I have chosen to focus first on assessment for my research.

### Research Questions

My primary action research question was, “What are the effects of crib sheets compared with open notebooks on student assessment in an introductory high school earth science class?” A crib sheet, also known as a cheat sheet, is a student constructed paper that is used to provide help during an assessment. Most teachers stipulate the size and what it can contain.

Secondary questions investigated included:

1. How do students perceive the usefulness of crib sheets vs. open notebooks?
2. How do crib sheets impact student test anxiety?
3. What are the effects of crib sheets compared to open notebooks on the length of time students spend on an assessment?
4. How do the results of my research affect me as a teacher?

In my classroom I had once tried using crib sheets for a regular assessment. By regular assessment I mean a typical earth science unit quiz that follows a customary

format for my class. In that case it was not as successful as I had hoped. I found many students did not create a crib sheet and some students addressed very few topics on their crib sheets. However, a small percentage of high achievers used their crib sheet for success on the test.

I remember a chemistry class I took years ago in which the professor allowed us to make a crib sheet on a 4 x 6 inch index card. I wrote rather small, and though I don't recall using it, I may have referred to it during the test. The value for me was in the construction process - the collection, review, rewriting and organization of the material. Learning is what I believe is the chief benefit of crib sheet construction.

Test anxiety is used by some students as a means to justify their poor performance on assessments. It seems logical that reducing anxiety would be conducive to clear thinking and better results. I feel that many students rush through a test and don't take the time to analyze questions and answers. This is a topic in its own right, however my research may be the beginning of determining how test aids affect time on task and attention to details. How the results of my project affect me as a teacher underlies the reason for performing action research. If the teacher doesn't reflect, learn and grow then students can't be expected to either. As it has been declared, if one continues to do the same actions, one will probably reap the same results.

### CONCEPTUAL FRAMEWORK

Why would a teacher want to allow students to use pre-written notes on a test? After all, aren't tests supposed to demonstrate what students know and have internalized as learning?

As I reviewed literature about the use of crib sheets I found an ongoing difference of opinion between authors who said their research showed student improvement and those who said there was no improvement in student performance. I was hoping to resolve this discrepancy for myself through the action research model.

One idea in the literature is that the time and effort that students expend learning and teachers put into reworking of instruction could be used more efficiently and productively by allowing students to use crib sheets while taking assessments, or “make the exam notes a requirement” (Whitworth, 1990).

Whitworth (1990) noted that he had used crib sheets for fifteen years at student grade levels of junior high, high school and college. He felt that this strategy helped his students to advance in their learning. His use of what he calls ‘crib notes’ is to allow one 8 ½” x 11” paper, written on both sides. Whitworth found that he had to instruct his students in how to create these crib notes.

Whitworth’s gave his students an exam where they were allowed to use crib notes, but he had not instructed them in construction. This seemed to be a “now that I have your attention” technique, in that many students didn’t do well on that first exam; consequently they were ready to see how he proposed to help them with crib notes. Through this process he was able to discern his students’ abilities, and this gave him a starting point for questioning them. He also allowed his students to retain or throw out that first test grade.

Next Whitworth formed student groups where he selected heterogeneous members. Some students were successful test takers and others were students who had floundered.

As the students compared their crib notes they found that they varied significantly in content. These content differences reflected both quantity and organization.

His third step was to ask the students to figure out what to do in order to create better crib notes. This process was guided by Whitworth himself. Students needed to analyze the questions he had asked on the exam in order to fix their notes. His purpose for this activity was to develop class guidelines which were then listed on the board. Specific crib note content that he wanted them to recognize as helpful included the use of abbreviations, color coding, common letters, and keywords; utilizing chapter headings or instructor emphases; restating main ideas and concepts; prioritizing and recording only that information that a student didn't already know; finding effective examples; and adding pertinent facts. One of the most important parts of this strategy was that the students developed this list of guidelines themselves, and that it was created through their personal desire for improvement.

After going through the guideline process, Whitworth then checked students' crib notes to see if they were creating a satisfactory product that they could use. If not he worked with individual students to help them be more effective. Lastly he had students turn in their crib notes. He said, "If another disaster occurs, at least I will have a starting place in reteaching the necessary skills" (p.24).

Reducing dishonesty was one of Whitworth's original aims and as it turned out academic integrity was one of the benefits of using crib sheets. He found other positives, too, for example using crib notes tended to reduce test anxiety in students. He also pointed out a legitimate reason that students should be able to use crib sheets. Teachers use notes and PowerPoints when teaching. These serve as reminders of details and

concepts teachers want to elaborate on. He thought that students should be able to use tools for their recall, too.

A benefit that Whitworth touted is the enhancement of critical thinking skills. He attributed this to the students' need to go through class materials and perform analysis, synthesis, find relationships, make inferences, organize, and prioritize information to construct crib sheets. Whitworth felt that true learning was occurring as students 'remade' information in their own images, constructing personal meaning from the materials.

Elaborating on the theme of fair testing, educators at a nursing program in St. Louis, Missouri, studied using crib sheets (Drake, Freed & Hunter, 1997) as a treatment to reduce test anxiety, thereby freeing students to be assessed on their capabilities rather than their perceived incapacities.

The psychiatric/mental health nursing faculty of Barnes College of Nursing held a brainstorming session about ways they could reduce student test anxiety. They examined the reasons for this anxiety and determined that it was due to the students' first exposure to "higher order testing" that was conducted in a clinical situation with a patient. This testing required students to demonstrate mastery of new vernacular as well as new content, and to apply theory to their individual clinical situation.

Crib sheets or cheat sheets were considered as a method to reduce test anxiety. This anxiety was recognized as a "...valid, and frequently incapacitating, phenomenon..." (p.292). One goal of all their practice settings was the reduction of anxiety, and so the faculty set about to eliminate the covert practice of cheating by replacing it with the unconcealed practice of creating crib notes. One basis for their interest in anxiety was



Sullivan's theory of anxiety (1953) that "as anxiety increases, personal awareness is constricted... with a constricted area of awareness, the individual is unable to access data that are external to one's limited awareness" (p.293). The faculty hypothesized that any treatment which reduced anxiety would permit students better access to their knowledge base, thereby demonstrating their true application of knowledge as new but promising psychiatric nurses.

An interesting note about this study is the artifacts that were collected. The crib sheets were found to be unique, detailed and often intricate. Some students condensed 3000-4000 words on one standard notebook page! Students used color for emphasis and sometimes used photocopiers to reduce the print size. The faculty didn't feel they could make any sense out of these pictographs, but the students claimed otherwise. The students were asked about the usefulness of their crib sheets and typical responses were, "Yes, I can read it," and, "I know where everything is" (p 298).

Afterwards students requested the return of their crib sheets. The reason why is representative of our consumer driven, capitalistic culture. It was found that the students wanted to sell their crib sheets to others going through the nursing program! Upcoming students apparently thought that buying these might reduce their study time.

Drake et al. found that the faculty of Barnes College of Nursing had endorsed the use of crib sheets to reduce students' anxiety. Their findings were that crib sheets provided security (as self-reported by students), met individual learning needs, were a simple and available way to reduce anxiety, empowered students to control their test environment, helped students to think critically, and freed students from needless memorization.

This study described teachers who were interested in helping their students succeed. They accomplished this by identifying student needs in unconventional areas. The students needed to show preparedness for psychiatric nursing by demonstrating mastery of methods used in a clinical setting. The teachers determined that they could provide a more useful platform for their students to demonstrate mastery by reducing student test anxiety. This study was causal rather than formal, but it serves as a reminder that the action research process is about people. It allows the teacher to respond to the students that the research affects.

There are two competing ideas about the construction and use of crib sheets as put forth by Funk and Dickson (2011). These ideas originated from Dorsel and Cundiff (1979). One premise is the “coding hypothesis”. It postulates that through the procedures of choosing and categorizing information that is pertinent to an assessment, and further by rewriting and compressing this information into a format that will fit on a crib sheet, these actions of crib sheet construction will program that information into the student’s memory. Learning will have occurred through the preparation and use of the crib sheet during testing would be ancillary.

In contrast the “dependency hypothesis” (Dorsel and Cundiff, 1979) proposes that because students expect to have access to a crib sheet, they will rely on the crib sheet as a crutch to be used in place of learning. They will avoid analysis, review and study of the material they need to understand and therefore they will be unsuccessful in true learning. According to Funk and Dickson (2011) past studies have demonstrated that crib sheets do not improve exam performance. The substance of what constitutes a useful crib sheet is definitely a consideration in these arguments.

The study that Funk and Dickson performed started with fifty-one students in an introduction to personality class. The participants were predominantly female (93%). They were primarily college sophomores or juniors (76%), an age that could indicate they were familiar with college classes and preparation for exams. In other words they were not freshmen students trying to discern how the college game is played.

The methodology included multiple choice exams, first taken without crib sheets, and then taken with crib sheets. The instructor did help the students learn how to prepare crib sheets. To discern if learning was taking place because of the crib sheet preparation, students sometimes took a pre-test without using their crib sheets. Students also took another exam over the same material, this time using their crib sheets.

The findings were not in favor of the coding hypothesis. Students performed worse on the exam taken without the prepared crib sheet than when retested using the crib sheet. Though this does seem a logical conclusion, a different conclusion could be reached. Being exposed to the test questions a second time – even if reworded – could account for better performance the second time.

Funk and Dickson researched other studies with the conclusion that crib sheets do not improve student learning. They stated, “Past research has consistently found that crib card use does not improve exam performance (Dickson & Bauer, 2008; Dickson & Miller, 2005, 2006; Whitley, 1996). Crib card use did not increase exam scores in a social psychology course” (Whitley, 1996).

When conducting action research, qualitative data can provide insights that give the teacher researcher ideas about new methods to try. In one study (Hamed, 2008) students were allowed to use crib notes or cheat sheets for certain examinations. Hamed

demonstrated that it could be informative to look at students' crib sheets and investigate what they chose to record and why.

This study showed that higher performance was achieved when a test group used a crib sheet. Data was collected from students enrolled in the second semester of an algebra-based physics course. Topics included electricity, magnetism, waves and optics. Two sections of students were evaluated. Each section originally had 25 students with the number reduced to 22 in each class due to students dropping the class.

The treatment for this study was that students constructed an 8.5 x 11 inch cheat sheet that contained formulas, facts and any other concepts that students felt were necessary to include for their success. Students were sometimes allowed to use their physics textbook (Giancoli, 1997). The treatment was used for one class section for one test, then reversed and applied to the other class section. This effectively supplied a control group each time. For example, Group A students were permitted the study sheet while Group B could use the textbook for Exam 1. For Exam 2 the roles were reversed: Group A students could use the textbook while Group B was permitted their study sheets. This symmetrical treatment was a viable way to include two groups while trying to minimize singular results. To reference the rest of the data collected in this study homework during the semester could be completed using any of the aids, quizzes were not permitted any written aids at all, and the semester final was open for text use.

The researcher, Hamed (2008), gathered some very interesting data. He questioned his students to see if there was a correlation between student preference to use a study sheet and their score on the exam. He found that students receiving an A grade "preferred the sheet" and most of the students receiving a C and below preferred to use the textbook.

Students receiving a B expressed an equal preference for using a study guide or using the text.

Further questioning revealed that the students who liked the sheet were positive about their capacity to create a sheet that was organized with relevant information that would benefit their performance on the exam. They also worried that if the textbook was permitted then the exam questions would be more difficult. The author noted a potential area for more study. He thought that it might be valuable to take the SAT and GPA of students into account and use this data in his analysis and conclusions. However, since he found no statistically significant differences in the two groups, he felt they had similar abilities going into the study.

Another study examined students' use of notes and textbooks during open-book examinations (Boniface, 1990). Boniface detailed results showed percentage of time spent on various tasks during the exam including writing, consulting notes, and consulting texts. Boniface asked, "How much use is made of notes and texts during the examination? Are they being used as aide-memoire or being reprocessed wholesale into examination answers?" (p.203).

He found that an average of one hour was spent using notes or texts. Boniface decided that, "...very different strategies were adopted by different candidates." (p.203). This was his interpretation of the large variance in minimum and maximum time spent on various activities such as looking at notes or texts during the exam.

He also concluded that students' scores lowered when correspondingly more time was spent engaged in consulting the text. Students had been characterized from previous exams as strong (top third), middle (third) or weak (bottom third) students as determined

by previous exam scores. The data showed the strong students spent only 4.6% mean time on texts, while the weakest spent 11.2% mean time. One explanation was that stronger students had better notes and were more likely to use notes than a text. Weak students may not possess decent notes due to absences or they were less successful in understanding the course content.

This study discussed considerations about how to gather accurate data. Boniface employed two observers per trial who recorded data for every student at recurring five minute intervals. The observers were keyed by a ‘bleep’ that was audible only to themselves. They were positioned so that they had a clear view of the face and desk of each student.

In a qualitative part of the study the students were questioned about their preparations, perceptions, and feelings about the exam and use of notes. One of the questions was, “What message would you want to give to someone taking that examination next year; how could the person learn from your experience?” (p.206). Through analysis Boniface concluded that the responses supported the idea that students should prepare in depth as though they did not have access to resources. He also asked if use of notes was time well spent. Only twenty seven percent felt that they spent excess time more than once in reviewing notes – time that could be better utilized to answer another question. This indicates that most students felt having and using the notes as a resource was time well spent.

Though administering qualitative types of questions, the author was able to convert the answers in to quantifiable data sets. For instance, he awarded points of one, two, or three to corresponding responses ‘not at all’ through ‘more than once’. The advantage I

see in this approach is being able to consolidate some results into empirical data that can be represented graphically. A picture or graph often does more for clear and instantaneous understanding than paragraphs written about it.

A unique way of looking at the use of crib sheets was taken in a study that analyzed discarded crib sheets (Pullen, Ortloff, Casey & Payne, 2000.) The authors recognized that cheating is a pervasive concern in American schools. Their idea was to find crib sheets that students had thrown away and see what could be determined about crib sheet construction and cheating behavior. They were seeking answers for these types of questions: Which disciplines are frequently involved? What information is recorded? How are the sheets constructed? How are the sheets concealed? Where do students dispose of the sheets?

This study provided unobtrusive research by utilizing private archival material (Webb, Campbell, Schwartz & Sechrest, 1966). It was striking in its simplicity but it did take a lot of unconventional posturing to collect the data. The researcher charged with gathering data had to prowl the areas of one campus building, the Math/Science Building, and search through garbage to find small, crumpled pieces of paper – the cheat sheets. After gathering the data it was categorized using statistics such as mean, median, mode and percentage comparison. Analysis of academic misconduct using unobtrusive research a study of discarded cheat sheets

The authors found that there was a correlation between the number of cheat sheets discovered and the number of classes that were taught in a field; more classes yielded more cheat sheets. An exception was business courses which produced more sheets. It was postulated that a personal finance class had many facts and definitions that were

conducive to being written down (cheating). Math cheaters were in low proportions, possibly because math is a class that must be dominated by mastering skills along the way.

The content on the cheat sheets was classified as facts, formulas, definitions and concepts and the preponderance of usage was in that order. Facts were expressed fifty-eight percent of the time and concepts were evident just eight percent. The physical descriptions of the cheat sheets were almost comical. Students seemed to prefer writing on the corner of a page of rectangular paper. The paper tended to be 'soft' notebook style paper, perhaps because it is easier to fold and hide, then crumple and throw away.

An important point made was that this study did not explain how cheat sheets were used while students tested. It was the artifact, the actual crib sheet that was located and analyzed. It was found that cheat sheet use increased as time progressed later into the quarter. The authors concluded that as the pressure to receive good grades goes up, students are more disposed to incur the risk of cheating. The authors recognized that the incidence of cheating is probably much higher than what was indicated by the papers they collected because many if not most cheat sheets are disposed of where they weren't discovered by the researcher.

Students seem to believe that preparing a crib sheet will help them be better prepared to take an exam. A study by Bauer and Dickson (2008) confirmed this when they had students make crib sheets, then tested the students without using them, then retested the students again while using the crib sheets. In the course of their study they found that it was helpful for the instructor to coach the students in the preparation of their



crib sheets. The instructor emphasized choosing and arranging the information, and engaging in a review of the material rather than rote memorization.

The treatment consisted of asking the students prior to the first and third exams to construct an 8" x 11" paper with information from the course notes and text. The instructor suggested that they summarize concepts and try to understand how to apply these theories to specific circumstances. Students were then given an unannounced exam to take – without the use of their crib sheets – and later were tested over the material a second time. It was found that students received higher scores when using their crib sheets – the second time through the material. It is probable that one of the reasons they performed better was that they had already processed the questions once.

The students perceived that the construction of a crib sheet helped them to learn the course material and therefore increased their score on the exams. The data showed that 91.8% felt the crib sheet helped them to learn and 87.8% felt the use improved their test scores. 79.6% said that constructing the sheet reduced their level of stress.

An emphasis in modern secondary education is that students need to know how to quickly find appropriate information. They then can use their skills to apply this information to the problem they are solving. Soft skills are currently in demand – initiatives such as collaboration, communication, creative problem solving, and conflict resolution. I believe that the development of crib sheets or another successful intervention such as open notebook testing can contribute to this direction in education today – utilizing information rather than rote memorization.

The use of crib sheets while taking an exam instead of using science notebooks may encourage deeper learning. It would require students to construct their crib sheets prior to

the exam and be responsible for applying the information. I would like my students to interact with the material prior to the exam. I thought that determining what information is useful and condensing that information on a crib sheet would improve student outcomes on exams. Hopefully there would be little need to refer to their crib sheets because learning took place during the construction. However, the literature review yielded mixed results, where some studies showed student improvements but others did not.

## METHODOLOGY

### Sample and Demographics

My sophomore science classes these past several years have been integrated science or earth science. Previous to this I also taught freshmen biology, and since then I have taught algebra and math support. In March we conducted Criterion Referenced Tests (CRTs) for tenth graders. The week for science CRT testing has varied from the beginning to the end of March. My research goal was to have my treatment completed at least two weeks prior to testing in March. I needed time afterwards to conduct several short review lessons prior to the CRTs. The school year 2013-2014 was the last year for CRTs since testing changed to a new assessment, Smarter Balance.

My study pertained to two of my three sections of sophomore earth science. I used the data from two classes, periods four and six, to analyze for my research. The two classes had very different personalities. Every year I noticed quite a difference in students' attitudes from period to period. I have reflected on this many times and I have tried to make sure that I am not the variable, and that I bring the best "teacher-me" to every section. Nevertheless I still see differences. Some classes are engaged and seem to

enjoy science. Others have a disproportionate number of recalcitrant students. More than 56% of our students were identified as eligible for the free and reduced lunch program, an indication of the socio-economic status of the student population.

In consideration of ethics, fairness, best education practices and the learning outcomes of all of my students, all three earth science classes during my research received the same treatment. This provided the same potential benefits to all students, not only those in the study.

The data analyzed included period four, which was a very small class of nine students. I characterized five of those nine students as very concerned about their grade. Whether due to their disposition and effort, or the smaller class size, this class typically scored higher than the other two earth science classes. Out of six A grades earned the first quarter, period four had half of those. The other two sections (periods three and six) earned three A grades but this was out of 43 students in the two classes.

Period six was larger – twenty three students compared to nine in period four. It typically was a noisier, more outgoing group of students, and more of them seem to get off task. It was in the mid-afternoon, with one class before it and one after. I noted in my journal that, “I love these kids!” This notation was made early in the school year. Period six had four special education students.

I did apply the treatment and non-treatment to period three, but this class was not included in my AR project data and analysis. They received the same benefits or disadvantages as the other two classes. I felt that there would be too much data from three classes to analyze. I liked the fact that the two class periods I chose were different from each other and might help determine if different dispositions responded to the treatment

in different ways.

### Treatment

The study design for my research project was reviewed by the Montana State University Institutional Review Board (IRB), and was granted IRB exemption on December 4, 2013. A copy of this exemption approval is Appendix A.

The treatment was to allow students to construct and use crib sheets while taking summative assessments. The treatment was applied to the student participants and then alternated with my traditional approach. My traditional approach has been to allow students to use their science notebooks during assessments. I had hoped to repeat this cycle two times. The number of cycles was dependent on the testing schedule for our school and where I was in my action research project. Ultimately my data is from one complete cycle of treatment and non-treatment.

I had one 'trial run' where I asked the students to make a crib sheet and use it on the assessment. I looked at the crib sheets that students prepared. Less than half of the students made them. I found that students struggled with what to include from their notes and activities. I realized that I needed to provide guidance in constructing crib sheets. Students needed to know what information to review and include, they needed ideas about organizing the material, and they also needed class time to put it into practice.

Even with this help, the next time I tried the treatment of crib sheets many students chose to not create one or to make one of limited scope. Three students of seven made crib sheets in period 3. Only six students of twenty made crib sheets in period 6.

Non-treatment was allowing students to use their science notebooks on their summative assessments with the exception of the semester final tests. (For both

cumulative semester tests I did allow crib sheets. These were a printed study guide that students could write on. A typical semester test study guide was four pages long and I allowed students to write as much as they wanted to on these pages. Semester test data was not included in the research project data.) During a treatment unit students were not allowed to use their notebooks because they were to have prepared a crib sheet.

I conducted one treatment unit using crib sheets. For the crib sheets I permitted an 8.5 x 11 inch paper written on both sides. Two students asked to prepare their crib sheets on computer notes, which I allowed. I surmised that the value of a crib sheet was in collecting and organizing the information that goes onto it. The creation process was what supported learning. I encouraged my students to use keywords, color coding and small pictures when appropriate. My support grew to include giving the students notes of the specific vocabulary and science concepts they needed to know.

To reiterate, all three of my science classes were given the treatment, and I collected and analyzed data on two of those.

### Instrumentation

The data collection techniques I used included student Likert surveys to determine what students thought about open science notebook testing compared to using prepared crib sheets, pre-tests to provide baseline information about what students already knew, and summative assessments that were used to determine how student learning had changed after the teaching unit. I conducted student interviews of several students I thought represented some of the different attitudes towards learning. I recorded some of my thoughts through a journal of observations and reflections. This matrix illustrates the data collection tools that supported my research questions.

Table 1  
*Research Questions Matrix*

Research Questions	Student Survey	Pre-Test	Summative Assessment	Teacher Journal	Student Interviews
Primary: What are the effects of crib sheets compared with open notebooks on student assessment in an introductory high school earth science class?	√	√	√	√	
How do students perceive the usefulness of crib sheets vs. open notebooks?	√	√	√	√	
How do crib sheets impact student test anxiety?	√			√	
What are the effects of crib sheets compared to open notebooks on length of time students spend on assessment?			√	√	
How do the results of my research affect me as a teacher?	√	√	√	√	√

I was interested in how my students felt about high school science classes in general. I surmised that their attitudes had been formed prior to high school, but I wanted to get an idea of their current disposition towards science class. The sequence of science at School District 6 included science in grades six through eight, biology in ninth grade, and earth science in tenth grade. Additional science classes are optional. I decided to interview several students about their disposition to science.

To determine interview candidates I first asked for student volunteers. Students were instructed that the interviews would be about science education and not about science content. It was made clear that they were not being tested on academics nor were they being graded, but rather that their opinions about education were valuable.

From there I selected and interviewed four students from my classes. The students were told they were randomly selected from the volunteers; however I chose students who represented different achievement levels in science. The interview questions and student responses are documented in Table 2.

The data collected for my action research project was both quantitative and qualitative. I found the qualitative data more helpful than the quantitative data. I say this because the quantitative data was derived from a low number of students who constructed and used a crib sheet. There were not enough students who used crib sheets to draw firm conclusions based on the sparse quantitative data. I believe this reflects the amount of effort that many students put into science class and also how many did not prepare for assessments. These factors definitely affected students' test results. This pattern of low effort and low achievement occurred in my one section of algebra, too.

To understand this great variance in assessment performance, whether in earth science or my algebra class, I thought it was helpful to consider who my students were. My students are required to take these classes whether they want to or not. These classes are core classes for all students and most of our special education students are in the classes, too. Only the top students may bypass these with proper faculty approval.

I tried to build validity and reliability into the instruments. Quantitative data was taken from pre-test questions that were written based on the summative assessment questions for both treatment and non-treatment units. Quantitative data was also taken from the summative assessments. The change in score between pre-test and summative tests was computed and compared between the non-treatment and treatment units.

Starting times and ending times were recorded and I computed the time on the task rather than having students simply record their apparent time on the task.

I hoped my instruments demonstrated validity though it was debatable due to a lack of student participation in the treatment; many students didn't construct and use crib sheets. My students' scores were widely distributed with no definitive pattern. It was common in my classes that I did not see the 'bell curve' model in scores earned on most assessments. In fact the same student often showed widely varying test scores. One in particular, Student H, consistently varied in summative test scores from 31% and failing to near 85%. When I spoke to her on several occasions about her achievement she talked about several reasons. She wanted to do well and took the time to go through her science notebook. She was in a bad mood and didn't want to bother with preparing for the science assessment. She was mad at her mom and decided to use that as an excuse (her word) for ignoring the test.

Qualitative data taken seemed trustworthy to me. Students were informed that participation was voluntary and would not affect their grades. Students appeared to thoughtfully complete the surveys, in fact most were interested in my action research project. Likert surveys asked the same questions regarding the use of SNBs or crib sheets. I asked some students clarifying questions about their responses and tried to utilize this information in my understanding and analysis. I took observations and made my conclusions with as little bias as I could. In fact I believe the qualitative data was more informative for my purposes than the quantitative data; it didn't answer my primary question because of low student participation in the treatment.



## DATA AND ANALYSIS

This was my first action research project in my classroom. I felt the results did not give me the definitive answers I was looking for. I was not certain if my students benefited more from preparing and using crib sheets or using their science notebooks on earth science assessments. What rendered the data less than conclusive was that very few students prepared crib sheets, and those who did often created incomplete sheets.

### Students' Attitudes Towards Science

I was interested in how my students felt about high school science classes. Their attitudes towards science revealed a wide range of opinions regarding science class and their dispositions, which was not surprising. Their responses illustrate one of the major challenges for teachers and schools: how do we engage a variety of students? Individuals have such diverse opinions about what is relevant to them, and they also have different learning styles. While one student learns hands-on, another prefers reading text. One student likes to take notes, and another student does not. Question one was not included here because it was an ice-breaker, "What activity do you enjoy doing in your free time?"

Respondent 1 said science was "ok" and "easy". This student typically earned a low C grade on assessments in science. He found schoolwork easy but put forth minimal effort and so did not achieve to his potential. He demonstrated knowledge and it seemed that he learned a lot, but this did not seem to be reflected in his test scores. He hurried through assessments; his average length of time testing was about 15 minutes. This was more than 37% less time spent than the class average. He had plenty of ability, but not the desire to work hard. After high school, when he chooses an educational path, I believe he will apply himself more and show himself to be competent. I think he will study in a

field that he finds not only interesting, but financially rewarding. Currently the high school curriculum is not providing that type of motivation for him.

Respondent 2 deemed science “fun” and her “favorite”. She often asked clarifying questions in class and during assessments. Respondent 2 was observant and sharp, as demonstrated when she pointed out an error I had made in a test (repeating a multiple choice answer twice.) She was conscientious about completing work and turning it in on time, and earned an A grade on most tests. Though friendly and cheerful, she was also very task-oriented about her school work. She would be an excellent candidate for a Science Technology Engineering and Math (STEM) career, however she wants to pursue vocational arts, probably welding. I’m sure with her attitude and aptitude she will be successful.

Respondent 3 described science as “boring” and “required” and his attitude in class definitely supported his stated opinion. He was usually late with his assignments and they were frequently incomplete. He tended to express a negative attitude about learning activities, and when he ‘worked’ with a partner, his partner did the work while he usually copied. On the occasion when he did know and share some science knowledge, he would smile and speak up and he seemed proud of himself. I’m sure with greater effort he could have enjoyed this type of success much more frequently. To me it seemed as though he wanted better grades, but not enough to put forth the necessary effort. His grade was usually failing, and near the end of a grading period he would turn in makeup work and squeak by with a D. However, regarding subjects that interested him - sports, humorous YouTube videos and music – he became animated, positive, smiling and wanting to share with everyone in class.

Respondent 4 was typically a B student who demonstrated persistence and was sometimes frustrated. She was determined to do well, but she had to apply herself and put forth effort to learn the material. She was the hardest working of the four students I interviewed. I don't believe that she will ever find school easy. However because she has made the choice to work hard and to place attitude before aptitude, I think she will be successful in her education and career goals. This determination will serve her well in the challenges that life tosses her way.

Table 2  
*Attitude Towards Science*

Interview Question	Responder #1	Responder #2	Responder #3	Responder #4
2. What two words would you use to describe science class?	Ok, easy	Fun, favorite	Boring, required	Useful, college
3. Do you see yourself taking another science class in high school?	No	Yes	No	Yes
4. Do you find science interesting?	Sometimes	Yes	No	Sometimes
5. What part of science class do you enjoy the most?	Labs	Labs	Not really any of it	Labs
6. What part of science class do you like the least?	Notes	Tests	Tests	Get tired of class
7. Do you feel like you understand science?	Yes	Usually	Yes	Usually

As I progressed through my action research project I began to think more about how important attitude is for student success. It would be interesting to study how attitude correlates with achievement and effort on summative assessments, whether using crib sheets or science notebooks. As teachers, how can we positively influence students' attitude characteristics such as perseverance and critical thinking - without being so

overbearing as to have students reject these actions simply because they don't want to be told what to do?

### Qualitative Survey Data

I administered two Likert student surveys that had questions relating specifically to the treatment and non-treatment in the action research study. Questions were about student attitudes to science, the connection between grades and their attitude, students' professed levels of test anxiety, and if there was a perceived value to using their science notebooks or crib sheets while taking an assessment.

This survey was first administered to consider use of students' science notebooks. Secondly it was given in regards to crib sheets. The scoring scale was from 1 which meant 'Strongly Agree' to 5 which signified 'Strongly Disagree'. The results and abbreviated questions are shown in the following table and figures. The data from class periods four and class period six are combined. The survey questions administered are listed in the appendices.

Results from period four clearly demonstrated that the students achieving higher grades were the ones with either lower anxiety levels or they showed self-determination to perform well. By the end of March only one student in period four wasn't participating in school sponsored sports. This indicated they had a reason (eligibility to participate based on grade) to perform better. Most had better attitudes. One female said science wasn't one of the subjects she liked. But she consistently put forth effort, did well on assessments, and earned an A for both semesters.

In the Likert student survey, I asked students to elaborate on Question 2, "I usually enjoy science class" by describing what they did or did not enjoy. Typical positive

comments included, “I like to learn new things” (two responses), “I enjoy the talks we have”, “I enjoy doing labs and experiments” (six responses), and “I enjoy science because it is interesting.” Some negative comments were, “I don’t like math problems” and, “It is boring, not this class, just science in general.”

I had expected positive student attitudes to doing labs and experiments. What I didn’t anticipate was how few students mentioned this. I tried to offer one science lab each week. This may be sufficient to satisfy most of the students. Two students expressed to me personally that they don’t like science class, while qualifying that it is not me the teacher, but rather science in general. This is an assurance builder and nice to know, however I’m fairly certain that some students don’t like me as a teacher, too. It is human nature to prefer certain personalities over others.

Students were asked to comment on their response to the question, “I try to do well in science class.” Common modalities were, “I (like to) do my best” or “I work my hardest”, which was recorded in six responses. “I need good grades” or “grades are important”, was recorded in five responses.

Negative expressions included, “I don’t like science” and “It’s hard I feel.” I thought these comments were attempts to honestly convey dislike of science. These types of comments are bothersome to me. I reflected often on what I can do differently or better. One student who had failed earth science the previous year said that he liked me but that he had never liked science and he wanted to be done with the subject. A female elaborated that she was fearful about getting bad test scores if the tests were too hard. She said that she hadn’t been successful in science in the past; she seemed to draw on that experience and projected an inability to ‘do’ science.

The data indicated that though they professed to be less anxious prior to testing when using crib sheets, in reality they anticipated greater anxiety with crib sheets and worried about poorer performance with crib sheets. What I found is that students rated themselves as less anxious (2.68 to 2.50) prior to testing when using crib sheets (CS) than their science notebooks. However they demonstrated the opposite in the next two questions, stating that their test anxiety was reduced more (2.25 to 2.54) when using science notebooks (SNB) and they felt their performance was enhanced (2.11 to 2.43) when using SNB.

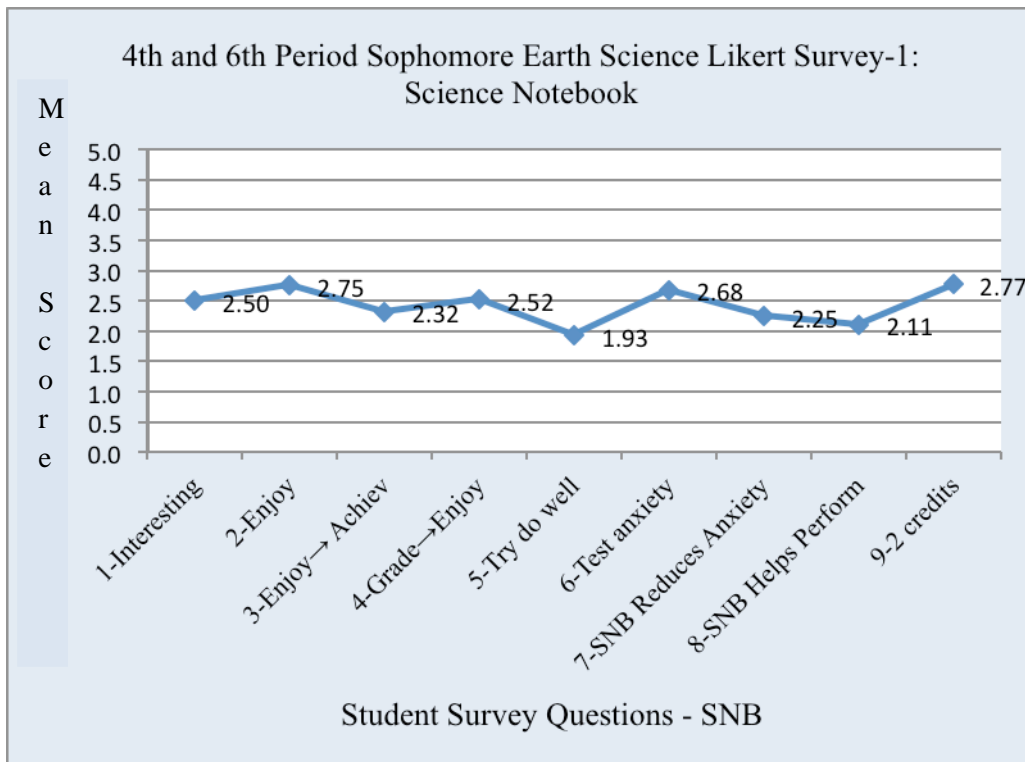


Figure 1. Likert Survey Given Prior to Quantitative Testing, Science Notebooks, ( $N = 27$ ).

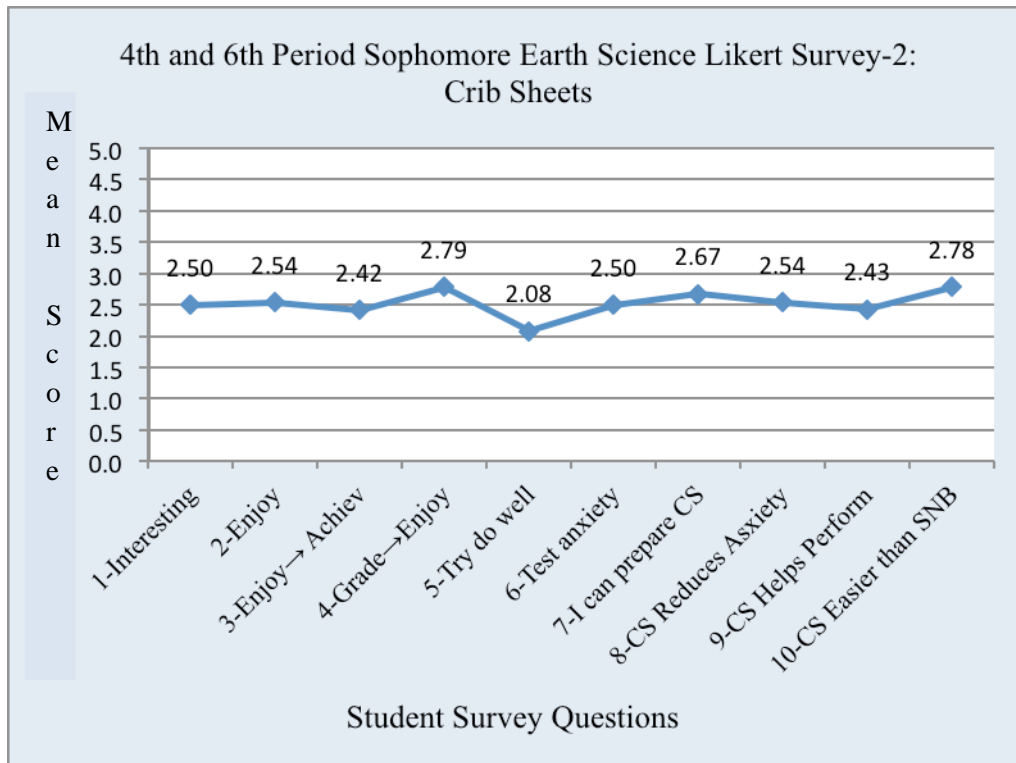


Figure 2. Likert Survey Given Prior to Quantitative Testing, Crib Sheets, ( $N = 24$ ).

The rating scale was: 1-Strongly agree, 2-Agree, 3-Undecided/Neutral, 4-Disagree, and 5-Strongly disagree.

Students responded to being asked to explain why they were anxious before a science test, if indeed they were. They said, “I’m really nervous I’m gonna fail”, “If I do bad, it will affect my grade badly”, “I freak out when it comes to taking tests”, “I have a hard time remembering some vocabulary”, “I can’t find my notes or can’t find the answer”, “Science is hard to understand,” and a three simply stated that they were scared or nervous without explaining why.

After I had gathered my data and was working on my interpretation of it, I began thinking about the students’ opinions of using a science notebook versus making a crib sheet. I issued a third Likert survey where I asked a new question. It was, “If given a

choice, I would prefer to use my crib sheet or my science notebook.” The sample size was  $N = 24$ , though only 21 of those students answered this question. I found that many students liked the idea of using crib sheets: 10 of 21 students stated a preference for using crib sheets. This was a much higher ratio than I had expected. I believe one of the reasons for this was because they had class and test experiences to relate the question to. Some of the typical comments included, “They contain only the information needed.” “They are organized and I don’t have to look through my notebook.” “It helps me to study.” “The answers are right there.” “I don’t know where to look in my science notebook.”

In contrast, students who preferred to use science notebooks usually mentioned one of two ideas. Often they didn’t want “...to take the time to make a crib sheet.” Some thought they already had the information, and they liked having their notes and other information handy for a better understanding.

During the busy days of instruction, student challenges and interruptions, it had seemed that most students were not concerned with grades. From these responses as well as from parent teacher conferences, it appears that many students are interested in good grades, some plan to attend college, and a few are considering STEM degrees. It is encouraging to me to know that some students care even when they don’t overtly show it. I was surprised at the number of students who expressed concern for their grades.

One implication of the Likert surveys is that this type of questioning can reveal student ideas that may be used to improve my classes throughout the year. I believe I need to utilize these early and throughout the year to add another dimension to my perceptions. For instance student “A” said that he liked to learn about science but found some activities pointless. This provided a great opportunity to delve deeper and find out



what he meant. It could have been that the activities were appropriate for the majority and just not to his liking. Or it could have been that his ideas of how to alter them would improve engagement and learning.

### Quantitative Data

The quantitative data included a pre-test over the concepts and science knowledge covered in my first two units of introductory chemistry. After the learning activities, which included labs, vocabulary, notes, and practice problems, students were given a summative assessment. Students were allowed to use their science notebooks for the summative assessment for this non-treatment phase of the research. They were then instructed to use a crib sheet for the second summative assessment. The data compiled shows the pre-test results as a percent and the summative assessment results as a percent. The change is the difference between the two tests and is listed as a numerical value. All students improved from the pre-test to the summative assessment.

Percent of change from the pre-test to the summative test was the method of comparison between the non-treatment and treatment units. Charts were compiled to show the variance among individual students; these charts are shown in Appendices H and I. The results were combined for the students in both class periods (See Figure 4 and 5.)

All students improved their scores from the pre-test when compared to the summative assessment. Students who scored 0% on the pre-test were entered with a score of 1.00. This is because their change from 0 to their summative score approaches infinity and becomes such an outlier as to be useless. I first tried entering a pre-test score of 0.01, but that was still extremely high in the percent of change.

Period four had a higher pre-test achievement than period six, with a mean of 25.67 % compared to 14.44 % for period six. The summative assessment results were 81.41 % for period four and 70.22 % for period six. The increase in achievement was greater for period six, however. They had a net change of 55.77 points from the pre-test to the summative test which is an increase of 1551.06%. Period four incurred a 439.21 % increase. The difference in percent increase is likely attributable to the low pre-test scores for period six. It is noted that their summative mean was still lower than period four's, too.

These results agree with my initial thoughts regarding the composition of the two classes. Period four is more concerned with grades and so these students may put more effort into their studies and test taking endeavors. The average grade for period four is 84% while the class average for period six is 71%. Period four is also a smaller class, nine students versus twenty two. Part of the grade differential may be due to keeping period four students engaged and on task as well as providing more assistance.

Percent of change from the pre-test to the summative test was the method of comparison between the non-treatment and treatment units.

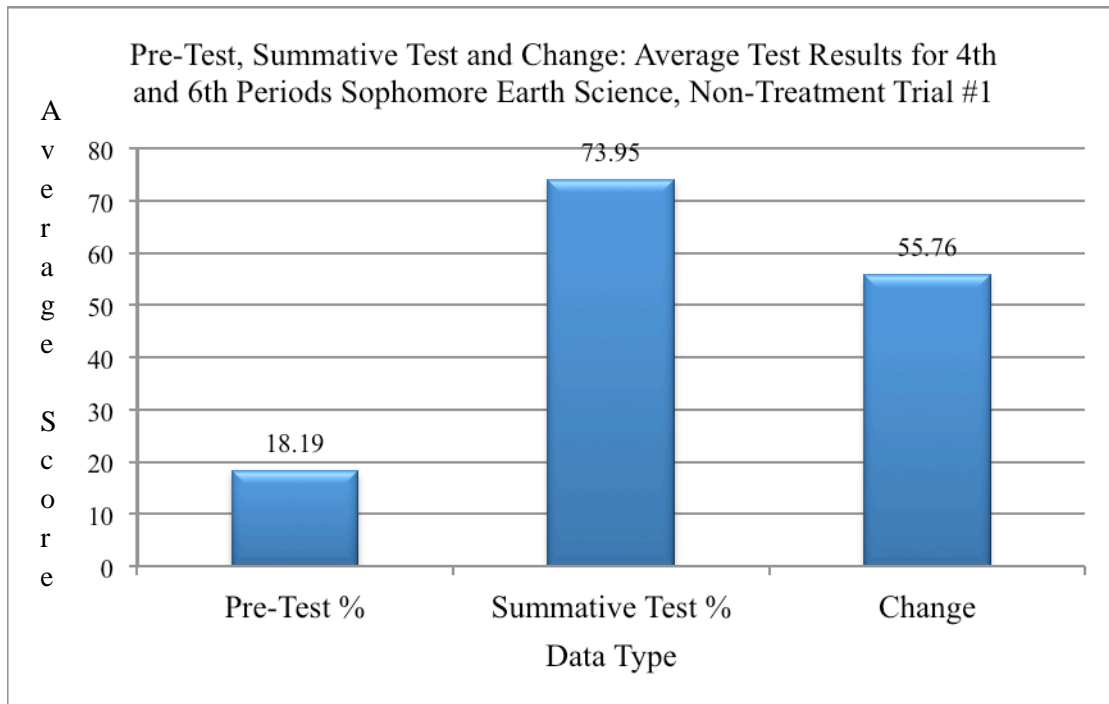


Figure 3: Non-treatment Results, Average for Periods Four and Six, ( $N = 27$ ).

Figure 4 illustrates the average totals achieved for both class periods. The data and results described here are for an initial non-treatment period.

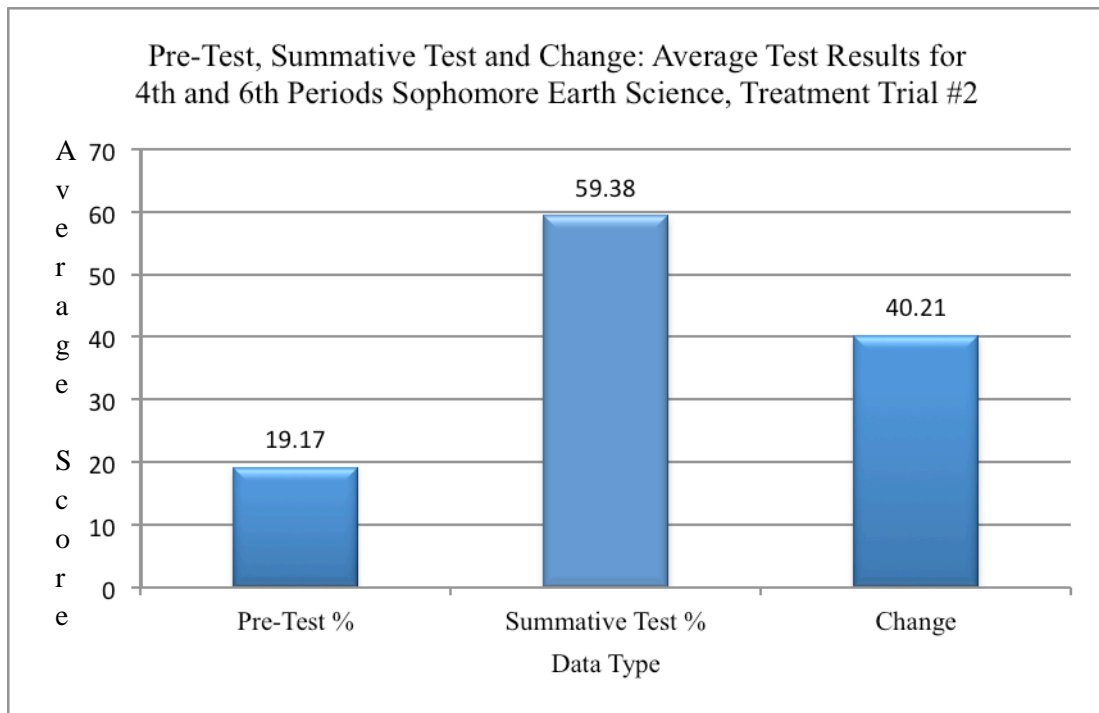
Another way to view this data is to look at normalized gain. Normalized gain takes into account the improvement (or not) of results when compared to the maximum possible improvement. It is computed as the difference between the post-treatment score and the pre-treatment score divided by one hundred minus the pre-treatment score.

Looking at normalized gain for these test results compiled in Figure 4, the following is revealed:  $(73.95 - 18.19) / (100 - 18.19) \times 100 = 68.2\%$  improvement. These are definitely positive results after teaching the first chemistry unit.

Comparing the results by looking at standard deviation shows a wide distribution in student achievement for the non-treatment results. Only five of twenty seven students fell

within one standard deviation when comparing the change from pre assessment to summative assessment. In absolute terms there was a maximum standard deviation of 7.15 among the students.

This high number of outliers may indicate a need for greater differentiation within the classes as the students vary so much in their interests, aptitudes and attitudes.



*Figure 4:* Treatment Results, Average for Periods Four and Six, ( $N = 27$ ).

Figure 4 illustrates the average totals achieved for both class periods. The data and results described here are for a treatment period using crib sheets.

Here are the results looking at normalized gain. Looking at normalized gain for these test results compiled in Figure 4, the following is revealed:  $(59.38 - 19.17) / (100 - 19.17) \times 100 = 49.7\%$  improvement. These are positive results after teaching the second chemistry unit, but the improvement falls below the 68.2% achieved in the previous unit of non-treatment with open science notebooks. I believe there are two reasons for this.

One, it is more difficult material, and most students have not been exposed to it before.

The second reason is that very few students made crib sheets.

The results comparison by looking at standard deviation shows the large differences in student achievement for the treatment unit. Again, only five of twenty seven students fell within one standard deviation when comparing the change from pre assessment to summative assessment. In this case in absolute terms there was a maximum standard deviation of 11.86 among the students.

Standard deviation highlighted typical results for my students with widely distributed achievement scores. I had expected more consistency and higher achievement in this unit than the previous non-treatment unit. However, standard deviation told a different story. One reason I expected better results was the material on geology was some that they had previous exposure to. This could have been the very reason they were less successful – it seemed familiar and they didn't see a need to study. After test results such as these, it might be good to have the students analyze why they think their scores were low.

#### Additional Survey

I conducted one last, unplanned survey that provided me with what I identify as the most useful information of my research. The survey was conducted the end of April 2014, and this was after time had passed from a previous crib sheet assessment in February. The results were that almost half of the students surveyed indicated that they saw the value of crib sheets for improving their assessment scores.

From my perspective and journal notations it seemed as though the students had become more thoughtful about what might be helpful for their academic success. I noted,

“What surprising results! I really didn’t think this many students appreciated the value of crib sheets... wow!” Their attitude might have reflected that we were near the end of the school year and the sophomores were maturing into juniors, an age that is generally more prepared to accept responsibility for their education.

### INTERPRETATION AND CONCLUSION

My action project research results seemed to mimic the mixed but common outcomes of what I found in my literature review. The literature review yielded widely varying results that crib sheets did help in one study, and did not help in another.

My quantitative results did not support the use of crib sheets for improvement in assessment scores. However my qualitative survey data indicated that crib sheets could be helpful for many students.

The following qualifications go along with the premise that crib sheets are useful. I need to assist students in crib sheet construction including giving specific topics and helping students organize and record this information. A system needs to be implemented that strongly encourages most students to prepare a crib sheet. It may need to be that students are not allowed to test until they have a crib sheet. They would receive an incomplete until both the crib sheet and assessment are completed. At CFHS an incomplete automatically converts to a failing grade after ten days at the end of a grading period.

I have found that the best students tend to utilize all strategies available for their success. Struggling students often don’t participate in learning activities such as note taking, critical thinking exercises and learning games or other preparation for

examinations. These students represent the population that might be best served by more thorough preparation; however they need a reason to be compelled to participate. When crib sheets were stipulated as a mandatory assignment, my hope was to see students benefitting from adequate preparation and the use of these.

In my study I found that my students who had a higher GPA such as those on Honor Roll generally performed well on science tests. They used the study tools available to them, especially their science notebooks. Not all of my higher performing students made a crib sheet. In my opinion they were successful because they analyzed the questions on the science assessments. At this level of curriculum, I believe this is one of the most valuable skills needed. It requires effort, thought and persistence to consistently analyze questions and possible answers.

#### Conclusions Regarding Secondary Questions

Consider how the study results address my secondary research questions. One question I wanted to investigate was how students perceive the usefulness of crib sheets vs. open notebooks. My last survey indicated that almost half of the students (48%) thought crib sheets were a good idea. Their primary reasons were they felt the information would be concise, readily available and they would be prepared for the test. Typical comments included, "It helps me study." "Answers are right there." "Only the stuff you need to know." "Organized & easier to find." They seemed to feel that constructing a crib sheet was worth the effort.

Another question was how do crib sheets impact student test anxiety? The difference between perceived anxiety levels whether using open notebook assessments or crib sheets was measurable on the qualitative scale. Using open science notebooks

students self-reported an average score of 2.68 (leaning towards disagree) versus using crib sheets with an average score of 2.50 (leaning towards agree.) This indicates a positive change of 7.2% where students thought that crib sheets were more helpful than notebooks. This isn't a large margin; I believe that anxiety is more of a personality trait than a result of tools used at school.

Consider the effects of crib sheets compared to open notebooks on the length of time students spend on an assessment. Students spent an average time of 25.6 minutes taking the non-treatment (SNB) assessment in Trial #1. Their average score was 60.9%. This compares to an average time of 19.1 minutes taking the treatment (CS) assessment in Trial #2 with an average score was 65.2%.

Students spent more time looking through their science notebooks and received a lower score for their efforts. Though the time difference of 6.5 minutes doesn't seem to be much, it was more than a 25% reduction in time spent that yielded students a 7.1% gain in their assessment scores. Some of this may be attributable to the subject matter.

Many students chose not to construct a crib sheet. The most impressive results are noted when the data is analyzed for those students who did. Those students averaged 17.9 minutes taking the CS assessment and earned an average score of 77.6%. They spent less time taking the test and their score was higher. When compared to the students who did not construct a crib sheet, their time testing was slightly higher but their score was significantly higher at 77.6% vs. 46.4% for those who did not make crib sheets. This indicated to me that there is value to using crib sheets. In order to encourage more students to construct and utilize a crib sheet it may be necessary to make it a required, graded assignment.



My last sub-question, how do the results of my research affect me as a teacher, have some implications. The primary one for me is that I want to utilize crib sheets from the beginning of the year. I would like students to expect to construct crib sheets and accept that it is a required obligation. I believe that learning occurs as students go through the processes of organization and reworking the information they have. Many students will not need their crib sheets because they will know the material.

I would like to train students to construct and use crib sheets. I identified the need for training based on the crib sheets I collected. First of all, very few students made them. Second, most were incomplete and therefore not what I would deem useful.

Perhaps students didn't know where to begin. I liken this to one of the processes that the English department is taking our students through to improve writing skills. An example is giving students a sentence "stem" to start their writing. For instance the stem could be, "I thought that (character name) showed bravery when she \_\_\_\_\_." Then students add several sentences with facts, actions or quotes to support their thesis.

In science students could be shown a model of a well-constructed crib sheet and possibly a poor one, too. They would need a list of topics, concepts and vocabulary that they would be tested on. Many students accomplish more work with a partner, so I would try completing the first two crib sheets as a partner or group effort.

No matter how we encourage, coach, offer or demonstrate science to our students, I believe that the key to learning is active engagement on the part of the learner with a purposeful lesson. Engagement means that one is attentive and observing what is presented from the context of the presentation. Purpose determines the context of the material or what the lesson is trying to impart to the learner. Active means that the learner

is processing the observations whether this is apparent inwardly or outwardly. From my classroom observations and the testing success or lack of it that my students demonstrated, I truly believe that crib sheets can be helpful for student learning. To reiterate, I have very little quantitative data as so many students chose not to construct crib sheets. But my qualitative data supports this proposition.

Teachers have a responsibility to their students to encourage active engagement and participation through their lessons, connections and activities. Students have a responsibility to try to remain attentive, listening, observing, seeking information and participating.

Ultimately summative assessment for many students may be more a reflection of their engagement in lessons than their efforts to demonstrate what they know. I hoped that by trying the new treatment, the use of crib sheets, that I could get my students to consciously focus on their learning and thereby improve their knowledge and test scores.

My desire is that my students have multiple opportunities to interact with the topics we study. My hope is that they will take away new understandings and appreciation for science and the methods that science employs, including an improvement in scientific thinking. Scientific thinking is demonstrated by the analysis of information and the formation of logical conclusions that are evidence-based. Scientific thinking requires the ability to dig deeper, ask hard questions, examine one's beliefs, and be open to embracing a result that may differ from what the scientist – or student – initially envisioned. I believe that scientific thinking can be helpful in many areas of a person's life, such as being able to explain yourself to others and examining why one believes what they accept

as truth. Scientific thinking can also be used when a person is making a decision and she/he wants to be able to stand back and take a less emotional view of the proposal.

I have established that I believe the study of science has value for a person's life, and not just an academic career. So how can learning, assessment and more specifically the tools used in assessment contribute to the study of science?

When students are about to demonstrate what they have learned by taking an assessment, several reoccurring themes come up. Comments I commonly hear include: I'm not ready/not prepared; I was absent last week; I lost my assignments; this stuff is easy; I'm sick; I'm scared; I don't take tests well; let's just do this already; can I take it tomorrow; and the inevitable class leader who says something like 'stop whining and just do it already.'

In order to address student needs – more than half the class population usually voices an aversion to testing – I have tried various ways to help students become better test takers. At this point in my teaching profession I am ready to scrutinize my methods and see if they are helping students improve their learning outcomes or not. Test anxiety is one issue that needs to be considered.

Math is the language of many sciences, and necessary for describing and predicting scientific results. Some students have expressed a dislike for math in science. One suggestion regarding this was to clarify to students up front that though math may seem challenging they need to do their best to understand it. I feel it is valuable for students to relate math to science and to engage in mathematical problem solving. If one or two students a year has a "eureka" moment where the connection makes sense, then it is satisfying to me as a teacher. An example of this is graphing velocity vs. time for toy car

experiments when we test how far cars travel from a varied incline. With guidance, a few students understand the idea of displacement as the area under the graph, meters per second \* seconds = meters. In our activity this is one-directional, simply the distance traveled.

I have a belief that students who take good notes and save assignments with correct answers and logic can use these materials to help them study for an exam. My notes in my observations support this idea. In order to encourage students to actively participate in notebook and assignment work I have allowed them to use these items while taking summative assessments. I also believe that the more opportunities a student has to interact with the material, the more likely he or she is to learn from it. To me this means that a student who is looking for reinforcement or understanding of a concept in her/his notebook or crib sheet, has another chance to make a connection with the material.

#### VALUE

How has my project affected me as a teacher? I have enjoyed the opportunity to experience action research in the classroom and I understand how it can be useful. I have learned that it takes time to gather data, both for myself as the teacher-researcher and for my students as they learn more about themselves as students. And the difficulties that were revealed were significant! I would counsel other researchers to use very specific descriptive titles for their data files and to add information that clearly stipulated what data those files included.

The greatest benefit for me in the immediate future is the hope and direction that this project has given me for next year. I am convinced more than ever – and this was justified by my latest survey data - that the use of crib sheets can aid student learning and

performance on assessments. When there is student buy-in to an idea they benefit from it. I also believe that students need instruction in preparing crib sheets, similar to what I have done for semester tests.

My plan for the 2014-2015 school year is to utilize study guides and crib sheets from the beginning in my classes. Then my students will accept this study procedure as the norm in my classes, and I believe they will be more willing to put forth the necessary effort. It will require me to be organized and prepared. I usually rewrite my assessments throughout the year. These will have to be written early enough that I can guide the students in the construction of their crib sheets.

I am excited about the prospects for improving student outcomes in learning about science. We are all stakeholders in improving our students' education and the future opportunities that education will open up to them. For better or worse students must take many tests throughout their public school experience. Many tests are state and federally mandated and there are numerous subject and school district tests. Funding for school districts and the inevitable public discourse are all affected by students test results.

Teaching methods that improve students' test scores will benefit the students and teachers in my science department and possibly in my math department as well. I see applicability in using crib sheets in subjects such as history, literature, psychology and others. As teachers at CFHS we are beginning to collaborate regarding teaching activities. I hope to share a positive message with my professional work partners – that the construction and use of crib sheets can improve student test performance.

Action research in the classroom is about a teacher's personal efforts to address their students' education and also teacher needs. My efforts and analysis have resulted in

renewed enthusiasm for me and some changes in my protocol. This research however, has led me to the idea of looking at an entirely different inquiry to investigate.

I hadn't anticipated the issue that has come to the forefront through my teaching and research this past year. My concern is that student participation in learning activities is the lowest I have experienced in my eight years of teaching. This could lead to a different action research project. I don't yet have research to base this upon, but here is the crux of my observation.

About forty percent of my algebra students are failing. I think the primary reason for this is only five of fourteen (the class size has decreased from eighteen) students regularly complete and turn in assignments and three others attempt to catch up later. Usually there are only one or two students who take notes and write down sample problems on a daily basis.

In earth science, a sophomore level class, more than eighty percent are passing. However, it is a struggle to get many students to that point because they are behind on their assignments. I continue to accept late work, though this may actually reinforce unwanted behavior. I have also employed practices such as allowing test corrections. Common behaviors I see in both classes are students playing with their cell phones, students not keeping up with the daily work, and students not performing well on summative assessments.

It seems to me that students who do not participate in their education have reached epidemic proportions. Other teachers I have spoken to have confirmed that it is this way in their classes, too. The teachers from the junior high have warned us that next year's freshmen are the worst class they have seen for poor grades due to behavior and lack of

trying. At the junior high students can fail one class, and many of them have chosen to fail math. This has been confirmed in parent conversations.

The issue of greatest importance in the next few years seems to me to be how to get students to value their education and participate in it. This could lead to a qualitative study of what today's students truly believe. As teachers we have looming responsibilities such as the Common Core and the Next Generation Science Standards. But these education dictates will have little effect on learning if we don't address the underlying dilemma of apathy among students.

My desire is that my students have multiple opportunities to interact with the topics we are studying. My hope is that they will take away new understandings and appreciation for science and the methods that science employs, including an improvement in scientific thinking. Scientific thinking is demonstrated by the analysis of information and the formation of logical conclusions that are based on evidence. Scientific thinking requires the ability to dig deeper, ask hard questions, examine one's beliefs, and be open to embracing a result that may differ from what the scientist – or student – initially envisioned. I believe that scientific thinking can be helpful in many areas of a person's life, such as being able to explain yourself to others and examining why one believes what they accept as truth. Scientific thinking can also be used when a person is making a decision and she/he wants to be able to stand back and take a less emotional view of the proposal.

The perceived emphasis in modern secondary education is that students need to know how to quickly find appropriate information. They then can use their skills to apply this information to the problem they are solving. Soft skills are currently in demand –

initiatives such as collaboration, communication, creative problem solving, and conflict resolution. I believe that the development of crib sheets or another successful intervention can contribute to this direction in education today.

I hoped that my AR would show that the use of crib sheets improved students' test performance and that I could recommend expanding their use. On the other hand if crib sheets proved entirely worthless, then it would be an idea to discard for the present time and to concentrate efforts elsewhere. What I decided is that my results were a mixed bag with no clear dictate to recommend crib sheets instead of open notebook testing.

Teachers are bombarded from many directions with blame for the state of public education in America. It is easy to get caught in the trap of negative thinking. The purpose of my research was not to discuss youth culture or overall motivation. However, one outcome of my journal notes included this quote, "Remember the good stuff!" I want to record more of these to help encourage myself through the difficult times. I have been blessed with many supportive parents and wonderful students, with energy and enthusiasm and hopes and dreams, young people who I have had the pleasure to get to know better. I can't imagine a more challenging yet rewarding calling than I experience daily. It was a reminder to me that there are many moments of joy each day!



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APPENDICES

APPENDIX A  
DESIGNATION OF RESEARCH AS EXEMPT



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 0000165**

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**MEMORANDUM**

**TO:** Krista Martens and Walter Woolbaugh  
**FROM:** Mark Quinn, Chair *Mark Quinn ET*  
**DATE:** December 4, 2013  
**RE:** "Effects of Crib Sheets Compared to Open Notebooks on Summative Assessment in an Introductory High School Earth Science Class" [KM120413-EX]

The above research, described in your submission of December 4, 2013, 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  
LIKERT SURVEY 1



APPENDIX C  
LIKERT SURVEY 2

Name: \_\_\_\_\_ Student ID# \_\_\_\_\_

**PT Student Survey – Please circle the number representing your thoughts**

Participation in this research is voluntary; Participation or non-participation will not affect a student's grades or class standing in any way. Your data & opinions will be reported anonymously.

**1=Strongly agree 2=Agree 3=Undecided/Neutral 4=Disagree 5=Strongly disagree**

- |   |   |
|---|---|
| 1) Science is interesting.<br>1   2   3   4   5 | 6) I'm anxious before I take a science test.<br>1   2   3   4   5 |
|---|---|

If 1 or 2, explain why you are anxious:

- |  |   |
|--|---|
| 2) I usually enjoy science class.<br>1   2   3   4   5 | 1 |
|--|---|

Describe what you do enjoy:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

- |   |   |
|---|---|
| 3) My enjoyment of science class affects my achievement.<br>1   2   3   4   5 | 7) I can prepare a crib sheet.<br>1   2   3   4   5 |
|---|---|

- |  |  |
|--|--|
| 4) My grade in science class affects my enjoyment of science class.<br>1   2   3   4   5 | 8) The use of a crib sheet reduces my test anxiety.<br>1   2   3   4   5 |
|--|--|

- |  |  |
|--|--|
| 5) I try to do well in science class.<br>1   2   3   4   5 | 9) The use of a crib sheet helps me perform better on a science test.<br>1   2   3   4   5 |
|--|--|

Why did you answer the way you did in the above question?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

- |  |
|--|
| 10) A crib sheet is easier to use than my science notebook.<br>1   2   3   4   5 |
|--|



APPENDIX D

PRE-TEST CHEMISTRY: ATOMS, WHAT DO YOU KNOW? NON-TREATMENT

**Pre-Test: What do you know about atoms?** Name \_\_\_\_\_ Per \_\_\_\_\_

Particle:	Where is it located?	What is the charge?	What is the relative size?
Proton	1.		
Neutron	2.		
Electron	3.		

4. Nitrogen (N) has an atomic number of 7. What does the number 7 tell you about this element? It gives the i \_\_\_\_\_ of the element, and also tells the number of \_\_\_\_\_ that a nitrogen atom contains.

5. Nitrogen (N) has an atomic mass of about 14. What does the number 14 tell you about this element? \_\_\_\_\_

6. Nitrogen (N) has seven protons. If the nitrogen atom is electrically neutral, how many electrons does it have? \_\_\_\_\_

7. Argon (Ar) has an atomic number of 18 and an atomic mass of about 40. How many neutrons does Argon have? \_\_\_\_\_

8. Sodium chloride (NaCl) is salt. These two elements are joined together by an ionic bond. Describe an **ionic** bond: \_\_\_\_\_

9. Carbon dioxide (CO<sub>2</sub>) contains covalent bonds. Describe the difference between a **covalent** bond and an ionic bond: \_\_\_\_\_

10. Draw a Bohr model for fluorine. Atomic no = 9          Atomic mass = 19

11. Where are the valence electrons located? \_\_\_\_\_

12. What property of atoms (elements) do valence electrons determine? \_\_\_\_\_

13. Choose the correct word: Atoms are made of mostly [ empty space **or** solid particles ]

14. Water is a polar molecule. What does **polar** mean? \_\_\_\_\_

APPENDIX E

TEST: CHEMISTRY ATOMS AND ELEMENTS, NON-TREATMENT

Name \_\_\_\_\_ Period \_\_\_\_\_

Chemistry Quiz A: Atoms & Elements (61 pts)

Complete this table with information about the three main subatomic parts of atoms. (10 points)

<u>Subatomic Part</u>	<u>Charge</u>	<u>Location</u>
1.	2.	3.
4.	5.	6.
7.	8.	9.

*True or False – for clarity, write out the complete word, not just the first letter. (6 points)*

10. \_\_\_\_\_ The net charge on an ion will be negative if it loses electrons.
11. \_\_\_\_\_ The molecules in a gas are moving very rapidly and are usually far apart.
12. \_\_\_\_\_ Chlorine and sodium will form an ionic bond

*Write the letter of the term or phrase that BEST completes each statement or answers the question. Read and analyze every answer to determine if it is correct or not. (14 points)*

- \_\_\_\_\_ 13. Choose an accurate description of **valence** electrons:
- (A) located in the inner-most energy level      (B) electrons that have lost their (-) charge  
 (C) located in the outer-most energy level      (D) electrons that have migrated to the nucleus
- \_\_\_\_\_ 14. An **electrically neutral** atom has the same number of \_\_\_\_\_ and \_\_\_\_\_.
- (A) protons; electrons      (B) electrons; neutrons  
 (C) protons; neutrons      (D) protons; atomic mass units
- \_\_\_\_\_ 15. Two isotopes have the same number of \_\_\_\_\_ but a different number of \_\_\_\_\_
- (A) neutron; protons      (B) protons; neutrons  
 (C) protons; electrons      (D) electrons; protons
- \_\_\_\_\_ 16. Name the element that has **8 protons** and 7 neutrons.
- (A) Oxygen      (B) Boron  
 (C) Nitrogen      (D) Carbon
- \_\_\_\_\_ 17. Atoms in all materials above absolute zero (-273K) are \_\_\_\_\_. This \_\_\_\_\_ as temperature increases.
- (A) vibrating; increases      (B) vibrating; decreases  
 (C) unmoving; reverses      (D) unmoving; stays constant
- \_\_\_\_\_ 18. What state is described as having a definite volume and no shape?
- (A) solid      (B) liquid  
 (C) gas      (D) plasma

- \_\_\_\_ 19. These determine the bonding properties of an element  
 (A) the valence electrons (B) number of neutrons in each isotope  
 (C) total number of electrons (D) number of BFFs the atom has

**Match each term in the second column with the correct meaning in the first column; clearly write the letter in the blank on the left. (16 points)**

- |   |                         |
|---|-------------------------|
| ____ 20. Total average mass of protons & neutrons; no. of protons & neutrons                        | <b>A. element</b>       |
| ____ 21. Two or more elements chemically bonded in specific proportions                             | <b>B. atom</b>          |
| ____ 22. Region where electrons are located, a specific no. of electrons                            | <b>C. ionic bond</b>    |
| ____ 23. Chemical bond where the electrons are shared by the atoms                                  | <b>D. compound</b>      |
| ____ 24. Smallest particle of matter that retains characteristics of element                        | <b>E. atomic no</b>     |
| ____ 25. Chemical bond due to attraction of (+) and (-) ions; electron transfer                     | <b>G. atomic mass</b>   |
| ____ 26. Bond formed when electrons are shared by metal atoms bond                                  | <b>H. covalent bond</b> |
| ____ 27. Substance that cannot be broken down into simpler substances by chemical or physical means | <b>I. ion</b>           |
| ____ 28. An atom or molecule that has a net (+) or (-) charge                                       | <b>K. metallic bond</b> |
| ____ 29. Number of protons of an element; determine identity  | <b>L. energy level</b>  |

Complete #26-30 for this element when electrically neutral: Phosphorus. See the book pp 36-37 (5 pts)

30. What is its Atomic #? \_\_\_\_\_  
 31. What is its Atomic mass? \_\_\_\_\_ (rounded to the nearest whole number)  
 32. How many protons does it have? \_\_\_\_\_  
 33. How many neutrons does it have? \_\_\_\_\_  
 34. How many electrons does it have? \_\_\_\_\_

35. (5 pts) To the right, neatly draw the Bohr model of Phosphorus. Include the **quantity** of each of the three parts, their **locations**, and their **charges**.

**Include:  $p^+$ ,  $e^-$  and  $n^0$ .**

36. A calcium ion lost two electrons and is no longer a calcium ion. (2 pts) \_\_\_\_\_



APPENDIX F

PRE-TEST: ROCK CYCLE, IGNEOUS AND METAMORPHIC ROCKS,  
TREATMENT

Name \_\_\_\_\_ Period \_\_\_\_\_

PRE-TEST Rock Cycle, Igneous & Metamorphic Rocks (18 pts)**Complete the concepts with appropriate earth science terminology. (3 points)**

- \_\_\_\_\_ is molten rock that is found beneath Earth's surface.
- The molten rock that reaches Earth's surface is called \_\_\_\_\_ when it is still liquid.
- Rocks at Earth's surface experience \_\_\_\_\_ as they are broken down into smaller and smaller pieces.

**Write the letter of the term or phrase that best completes each statement. (6 points)**

- \_\_\_\_\_ 4. For metamorphic rock to become igneous rock, it must first be \_\_\_\_\_ & \_\_\_\_\_  
 (A) exposed and eroded (B) buried and under pressure  
 (C) exposed and weathered (D) buried and melted
- \_\_\_\_\_ 5. The chemical composition of a rock is most likely to change when the rock is:  
 (A) weathered and eroded (B) buried by deposition  
 (C) in contact with a hydrothermal solution (D) near an oil deposit
- \_\_\_\_\_ 6. Metamorphic rock is formed by \_\_\_\_\_  
 (A) immense heat and pressure (B) totally melting the rock  
 (C) both A and B (D) neither A nor B
- \_\_\_\_\_ 7. Very slowly cooling, intrusive igneous rock forms crystals that  
 (A) are quite small or fine grained (B) are not crystals; glass is formed  
 (C) are very large or coarse grained (D) their size cannot be predicted
- \_\_\_\_\_ 8. A foliated metamorphic rock is formed when crystals  
 (A) combine and form visible bands (B) dissolve & do not form visible bands  
 (C) align themselves parallel to the forces (D) become less compacted
- \_\_\_\_\_ 9. The metamorphic rock that forms from limestone is  
 (A) marble (B) schist  
 (C) quartzite (D) slate

**10. Complete the concepts with appropriate earth science terminology. (6 pts)**

The three rock types are \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_  
 \_\_\_\_\_. The \_\_\_\_\_ is the continuous process where one type of rock transitions into another. It is driven by plate \_\_\_\_\_ movements that cause regions of spreading and collision. The rocks are also altered by weathering and erosion, and earth processes that cause melting, \_\_\_\_\_ & pressure, burial or eruption, and geo & hydrothermal exposure.

**Circle the best answer of the two choices given. (3 points)**

**II.** The geothermal gradient means that heat [ decreases *or* increases ] with depth in the Earth. The temperature change is about 15-30°C per km. This means that at 2 km, a deep gold mine would have a temperature difference of around [ 50 *or* 100 ] °C from the surface temperature. The geothermal gradient is caused by thermal energy from the [ Sun *or* Earth's core ].

APPENDIX G

TEST: ROCK CYCLE, IGNEOUS AND METAMORPHIC ROCKS, TREATMENT



Time ended: \_\_\_\_\_ Name \_\_\_\_\_ Period \_\_\_\_\_  
 Time started: \_\_\_\_\_  
 Time on test: \_\_\_\_\_ (by teacher)

Quiz A Rock Cycle, Igneous & Metamorphic Rocks **ROCK ON!** (61 pts)

**1. Complete these concepts by filling in the Blanks. (9 points)**

► The molten rock that reaches Earth's surface is called \_\_\_\_\_ when it is still liquid. It quickly cools to form an \_\_\_\_\_ igneous rock. An example of this is \_\_\_\_\_ rock which contains dark colored minerals.

► \_\_\_\_\_ is molten rock that is found beneath Earth's surface. When it solidifies it forms an \_\_\_\_\_ igneous rock. \_\_\_\_\_ rock is a light colored rock that forms from magma.

► Rocks at Earth's surface experience \_\_\_\_\_ as they are broken down into smaller and smaller pieces. These small, loose particles are known as \_\_\_\_\_. They undergo the process of \_\_\_\_\_ as they are transported by water, wind and ice.

**Write the letter of the term or phrase that best completes each statement. (20 points)**

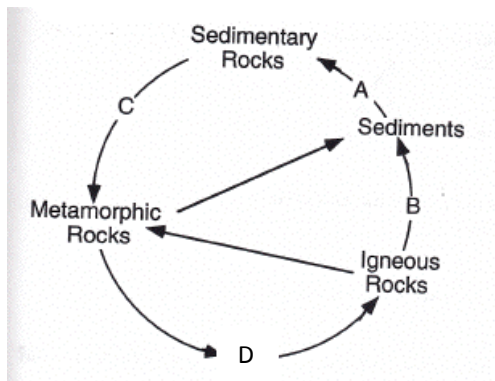
- \_\_\_\_\_ 2. For metamorphic rock to become igneous rock, it must first be \_\_\_\_\_ & \_\_\_\_\_  
 (A) exposed and weathered (B) buried and melted  
 (C) exposed and eroded (D) buried and under pressure
- \_\_\_\_\_ 3. When a rock is changed by its proximity to an igneous intrusion it is known as  
 (A) hydrothermal metamorphism (B) none of these is likely  
 (C) regional metamorphism (D) contact metamorphism
- \_\_\_\_\_ 4. The chemical composition of a rock is most likely to change when the rock is:  
 (A) in contact with a hydrothermal solution (B) near an oil deposit  
 (C) weathered and eroded (D) buried by deposition
- \_\_\_\_\_ 5. The identification test for marble applies \_\_\_\_\_ to the rock sample to see if it \_\_\_\_\_  
 (A) Mohs Hardness Test : scratches (B) acid : produces a precipitate  
 (C) limestone : turns into more marble (D) acid : produces CO<sub>2</sub> gas
- \_\_\_\_\_ 6. Metamorphic rock is formed by \_\_\_\_\_  
 (A) totally melting the rock (B) immense heat and pressure  
 (C) both A and B (D) neither A nor B
- \_\_\_\_\_ 7. Lava that cools so quickly the ions don't arrange into crystals before solidifying has a  
 (A) porphyritic texture (B) fine grained texture  
 (C) glassy texture (D) coarse grained texture
- \_\_\_\_\_ 8. Very slowly cooling, intrusive igneous rock forms crystals that

- (A) are very large or coarse grained (B) their size cannot be predicted  
 (C) are quite small or fine grained (D) are not crystals; glass is formed
- \_\_\_\_ 9. Choose the one of the following that is **not** an agent of metamorphism:  
 (A) running water (B) pressure  
 (C) heat (D) a hydrothermal solution
- \_\_\_\_ 10. A foliated metamorphic rock is formed when crystals  
 (A) align themselves parallel to the forces (B) become less compacted  
 (C) combine & form visible bands (D) dissolve & don't form visible bands
- \_\_\_\_ 11. The metamorphic rock that forms from limestone is  
 (A) quartzite (B) slate  
 (C) marble (D) schist

**12. Look at the two rock samples.** Choose the sample (A or B) that is an **igneous** rock. Identify the specific **igneous** rock by name: \_\_\_\_\_. What differentiates it from a meta-morphic rock? State at least 1- \_\_\_\_\_  
 \_\_\_\_\_, two differences. (6 pts) 2 - \_\_\_\_\_

**13. Complete the Rock Cycle using the four most appropriate terms or phrases. (8 pts)**

- hydrothermal precipitation
- melting
- heat & pressure
- subduction & convection
- weathering & erosion
- compaction & cementation



A = \_\_\_\_\_

B = \_\_\_\_\_

C = \_\_\_\_\_

**14. Complete the concepts with appropriate earth science terminology. (12 pts)**

The three rock types are \_\_\_\_\_, \_\_\_\_\_ and sedimentary. The \_\_\_\_\_ is the continuous process where one type of rock transitions into another. It is driven by plate \_\_\_\_\_ movements that cause regions of collision and spreading. Earth's rocks are also altered by weathering and erosion, and earth processes that cause melting, burial or eruption, geo & hydrothermal exposure, and the processes of \_\_\_\_\_ and \_\_\_\_\_ that form metamorphic rock.

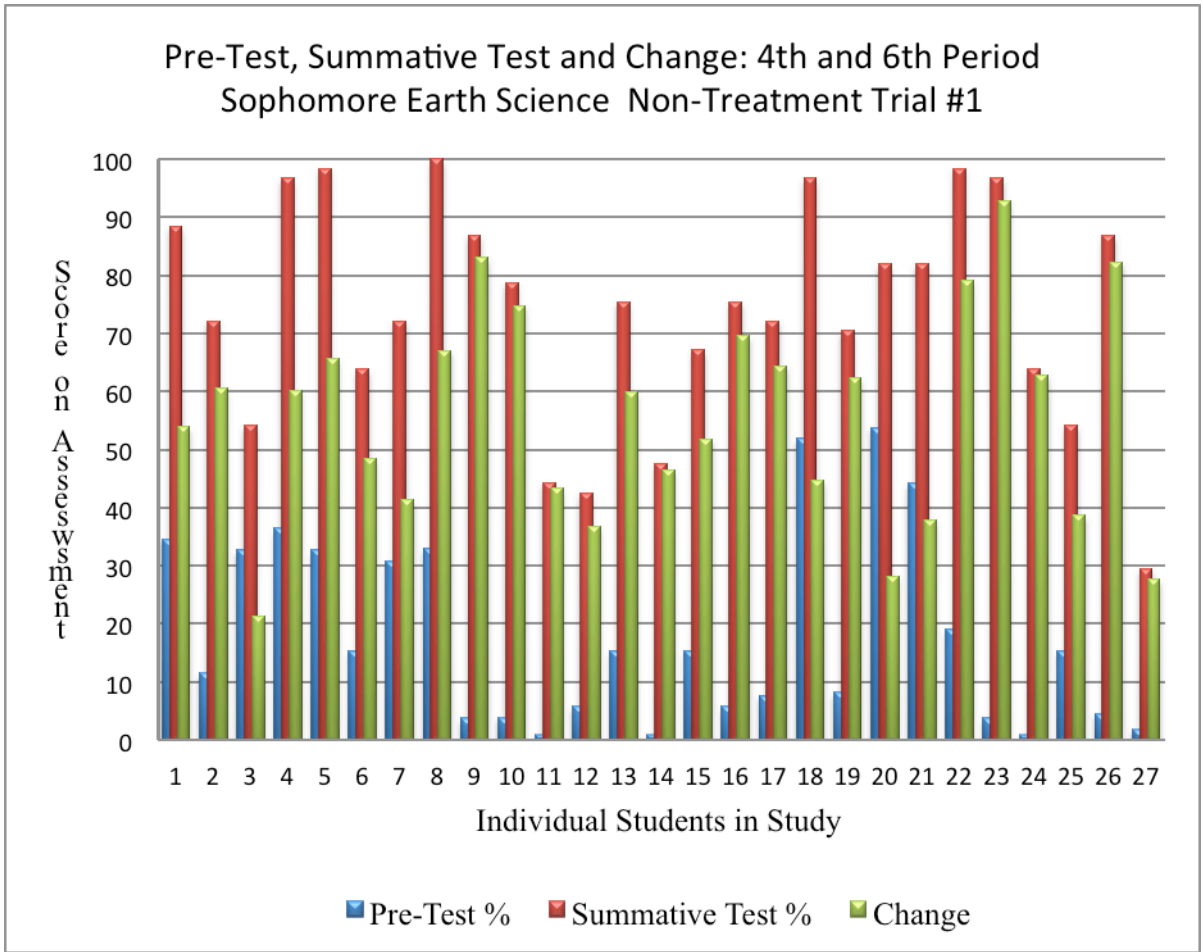
**Circle the best answer of the two choices given. (6 points)**

**15.** The geothermal gradient means that heat [ increases **or** decreases ] with depth in the Earth. The temperature change is about 15-30°C per km. This means that at 2 km, a deep gold mine would have a temperature difference of around [ 100 **or** 50 ] °C from the surface temperature. The geothermal gradient is caused by thermal energy from the [ Earth's core **or** Sun ].

APPENDIX H

PRE-TEST, SUMMATIVE TEST AND CHANGE - NON-TREATMENT TRIAL #1  
CHART

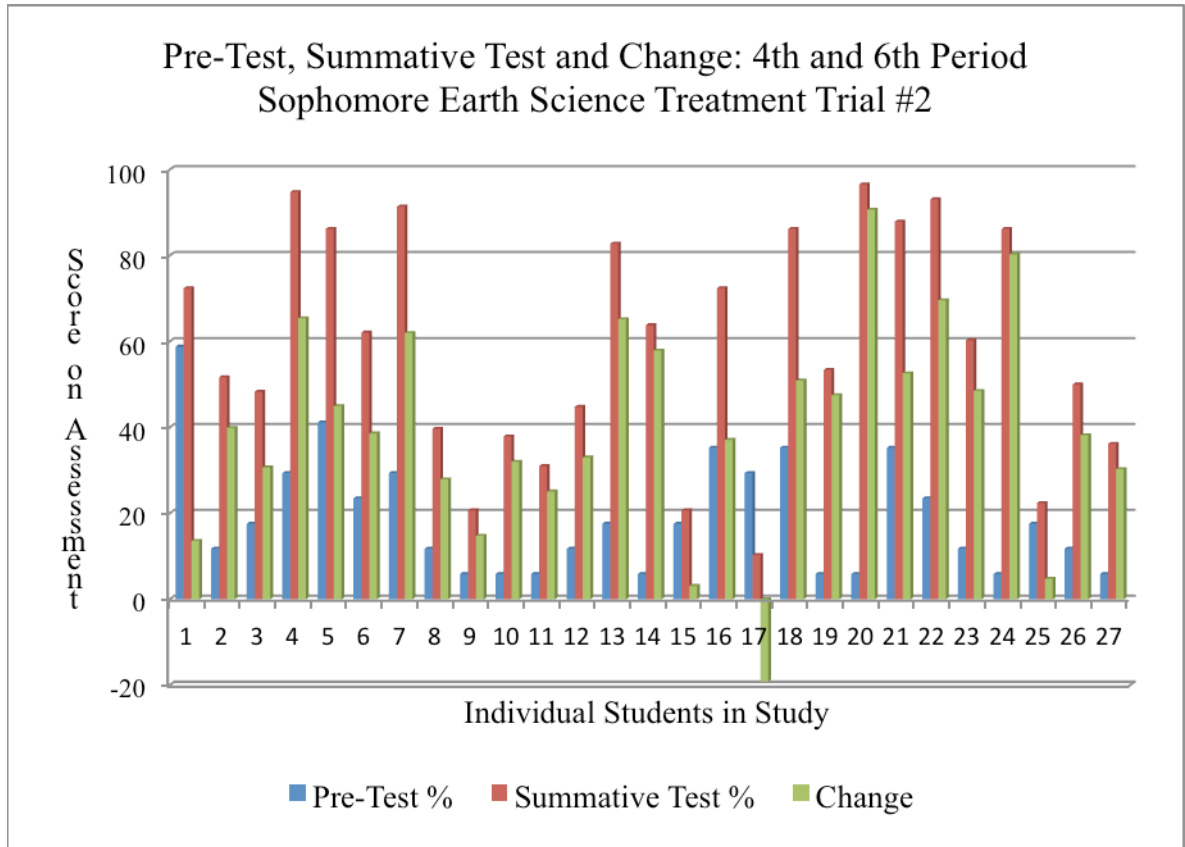
Pre-Test, Summative Test and Change: Non-Treatment



APPENDIX I

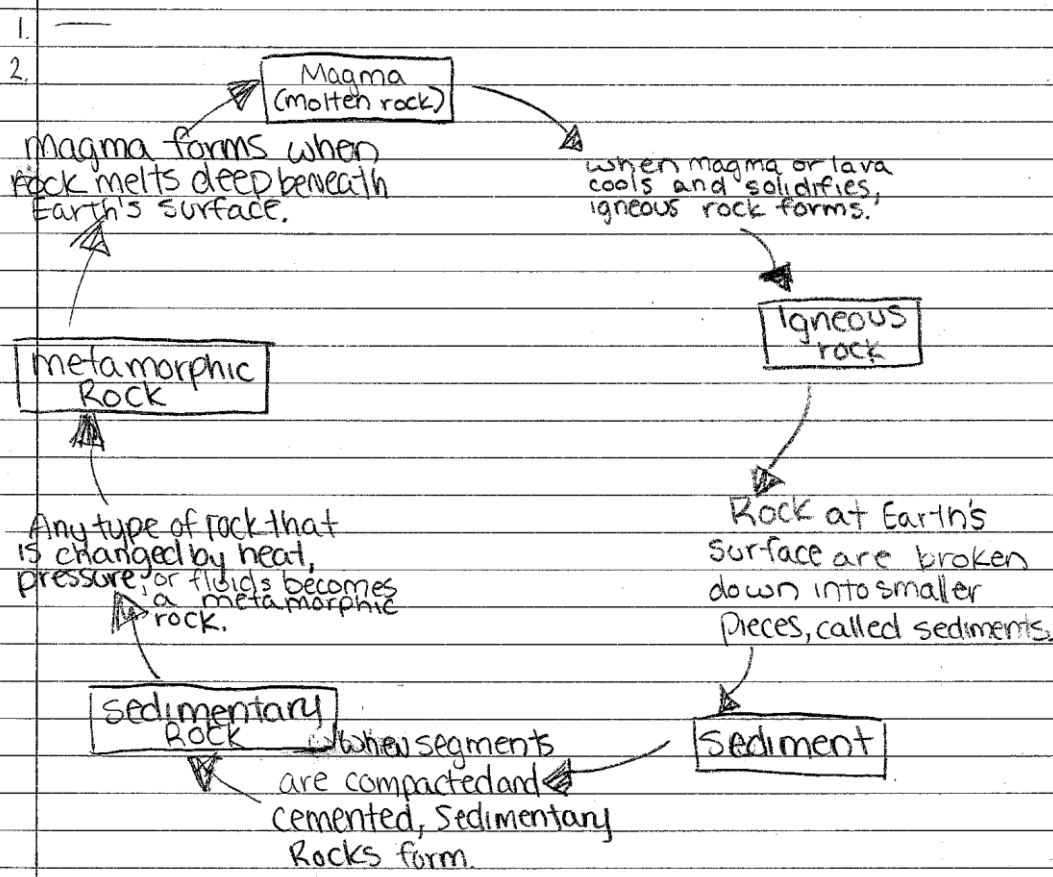
PRE-TEST, SUMMATIVE TEST AND CHANGE - TREATMENT TRIAL #2 CHART

Pre-Test, Summative Test and Change: Treatment



APPENDIX J  
STUDENT CRIB SHEET-1

Student Crib Sheet-1



3. sediments → what rocks, particles are named.

4.

5.



APPENDIX K  
STUDENT CRIB SHEET-2

2/2

11. NAME of Metamorphism due to an igneous intrusion? Contact Metamorphism  
When magma intrudes, contact metamorphism occurs.

12. What might change the chemical composition of a rock? Chemical weathering.

13. What is the ID test for marble? Warm hydrochloric acid, a positive test results in production of  $\text{CO}_2$ .

14. What is glass? (rock) obsidian and pumice

15. Cooling rate and crystal size? Slower cooling, larger crystals.

16. Compare/Contrast foliated and Non-Foliated.

Foliated Metamorphic Rock - a metamorphic rock with a texture that gives the rock a layered appearance.

Non-Foliated Metamorphic Rock - metamorphic rock that does not exhibit a banded or layered appearance.

17. Coarse vs. Finegrained

Coarse - slower cooling leads to larger crystals which gives the rock a coarse texture.

Finegrained - rapid cooling leads to smaller interconnected grains.

18. Contact metamorphism vs regional metamorphism

contact - During contact metamorphism hot magma flows into rock (igneous intrusion)

regional - results in large-scale deformation and high-grade metamorphism.

19. Sedimentary rock changes into → Metamorphic rock

shale → Slate

Sandstone → Quartzite

Limestone → Marble

→ Granite → Gneiss  
igneous rock