THE EFFECTS OF INTERACTIVE NOTEBOOKS ON STUDENT CONTENT KNOWLEDGE AND ACHIEVEMENT IN THE MIDDLE SCHOOL SCIENCE CLASSROOM

by

Katey Lynn Barber

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ABSTRACT

This study was aimed at determining what effect, if any, the use of interactive notebooks (INBs) in the science classroom had on student content knowledge and achievement. The general purpose of the study was to make notetaking a more engaging, meaningful, and productive means of learning for middle school students with a variety of learning styles. Seventh and eighth grade students were given a notetaking survey at the start of the year to assess their abilities with, attitudes towards, and confidence in notetaking. This survey was given again at the end of the study. Students were also given a questionnaire to determine whether they were primarily a visual, auditory, or kinesthetic learner. Each grade level received one treatment and one non-treatment unit. The non-treatment units involved students' own personal independent notetaking strategies using standard techniques such as vocabulary, definitions, main ideas, etc. The treatment unit involved the use of the Interactive Notebook (involving input pages consisting of teacher-provided materials and output pages consisting of student interaction with the teacher provided materials). Students were given a pre-assessment at the start of each unit and the same assessment was given at the conclusion of each unit to determine the effect each notetaking technique on student achievement. At the conclusion of each unit, students also self-assessed their science notebooks and scored their notes in several categories. In addition, student notebooks were assessed by the teacher at the conclusion of the units as well. Results of the study indicated that seventh grade students achieved more with interactive notebooks, whereas eighth graders showed little to no change in achievement. Neither grade level was more engaged with interactive notebooks as compared to standard notetaking techniques. Interactive notebooks benefited visual learners more than auditory or kinesthetic learners. Finally, students remain unsure of the usefulness of notes outside of class (both interactive and standard notebooks).

INTRODUCTION AND BACKGROUND

Context of the Study

This action research project was conducted at Havre Middle School (HMS), a Title I school serving grades six through eight in Havre, Montana. With a population of approximately 10,000 people, the community of Havre is considered by many to be the perfect size, not too small, not too large, and not too far from the Canadian border. HMS enrollment varies yearly, but at the time of the study, there were approximately 400 students attending school. Of these students, approximately 69% were white, 19% were American Indian or Alaska Native, 6% were two or more races, 4.7% were Hispanic/Latino, 0.5% were Black or African American, and 0.5% were Native Hawaiian or Pacific Islander. The student body was composed of approximately 51% female students and 49% male students, including almost two percent English Language Learners. Approximately 11% of the student population participated in the Special Education Program and 49% of the students were considered economically disadvantaged. The data for students receiving free and reduced lunches was unavailable at the time. The student-teacher ratio was 15:1 and all of the 26 full time teachers were certified (Institute of Educational Sciences, 2021).

At the time of my research, I was in my seventh year of teaching, all of which I experienced at HMS teaching science in grades six, seven, and eight. Over the course of the seven years that I have been teaching, there have been a variety of teaching strategies I have used, tried, and wondered about. Some of these strategies have been implemented successfully, while other strategies show room for improvement. One area of concern for myself as an educator as well as for my students is notetaking. Every year I have great intentions to help my

students develop purposeful and organized notetaking skills, but I always seem to run out of time or find an area of concern more pressing than that of notetaking. For this reason, I chose to focus my research project on developing a method of notetaking that is more engaging and meaningful, as well as useful and helpful to students.

Students seem to have various feelings and attitudes towards notetaking. There are some students who would spend the whole day writing, drawing, organizing, and color-coding their notes simply because they enjoy the process. There are others who could care less about taking notes, and there are those who despise writing and taking notes altogether. It was clear that I might not be able to change all student attitudes towards notetaking, but I strived to at least make the process more meaningful to students with the goal of showing students what a useful tool notes can be in any given content area. Whether students enjoy the process or not, at the end of the day I would like them to be able to recognize the many purposes of notetaking: to help build on content knowledge, to engage students in active learning, and to use as review and study materials in preparation for assignments and assessments.

As an educator, I would like to find a notetaking technique that is organized, engaging, easy to follow, and useful/meaningful to students. In my seven years of teaching up to this point, the notes that I help my students take seem to lack structure and organization. In other words, I could look at three different notebooks from students in the same class and see three completely different things. Through this research project, I hoped to find a technique that I would be able to use year after year without starting over from scratch. Ultimately, I wished to develop a template to refer to each year to prevent the need for rewriting or recreating notes for every unit, as this is what I have been doing each year up to this point.

A second goal from this project was the idea that my students would benefit by learning and developing organizational notetaking skills that they can use throughout the rest of their academic careers and beyond. I have some students who have their notes scattered randomly throughout their notebooks in no particular order, and other students who have their notes scattered throughout three or four random notebooks. For these students, notetaking is a complete waste of time, as chances are they will be unable to find the notes later to use for completing assignments, studying, or reviewing. These students need to view notetaking as more than just busy-work, and perhaps need a specific format to follow to stay organized. I wanted to be able to help them develop skills that they can use in multiple subject areas.

Science should be a hands-on engaging subject for students, so it is often hard to justify spending valuable time taking notes if students are just going to lose them or forget about them. Students, parents, and administrators alike need to be able see, read, and comprehend the end-product of the notetaking process for the notes to have any meaning. At this point, many of my students lack a clear idea of what the product should look like. However, if students are required to interact with and engage in the notetaking process daily and are required to use them as a learning resource, hopefully over time they will develop the organizational skills and detail to produce an end-product that is easy to read, understand, and use.

Focus Statement/Question

In my search to find and develop a more effective notetaking technique to use in my classes, I came across several resources, both within and outside of my school's curriculum, that contained or mentioned interactive notebooks. I had occasionally used some of the interactive notebook templates provided in our curriculum before for the sake of time but had never

investigated the structure, organization, or setup of interactive notebooks as a whole. Once I had decided upon notetaking as my research topic for my project, interactive notebooks were one of the first things to come to mind. Several teachers in different districts and states had posted on social media about interactive notebooks, but I had never dedicated the time to looking into how to effectively use an interactive notebook in the classroom. It became apparent that this research project would be the perfect opportunity to try this method of notetaking.

The overall purpose of my research project was multifaceted. For one, I wanted to help students develop the skills necessary to take meaningful, organized, and useful notes. Another purpose was to engage students in the notetaking process both inside and outside of the classroom setting. Finally, I ultimately wanted to teach students how to use their notes as a tool to guide and support their learning and understanding of the content. Once I had determined the purpose, it was easy to formulate my research questions, including one primary question and three sub-questions.

My focus question was, What is the effect of interactive notebooks on student content knowledge and academic achievement?

My sub questions include the following:

1. Are students more engaged in notetaking when using interactive notebooks as compared to standard note-taking techniques?
2. Are students more likely to use interactive notebooks than standard notebooks outside of class for the purposes of studying, completing assignments, and reviewing?"
3. Are interactive notebooks more effective at meeting the needs of multiple learning styles than standard notebooks?

There were several people who provided a great amount of assistance, support, and feedback in the design, development, and implementation of my action research questions and project. The two other science teachers in my building helped me refine my plan and specify exactly what my purpose was. They also provided valuable input as far as their own observations regarding student skills and application of notetaking techniques in their own classrooms. One of the other teachers had elementary experience using a version of interactive notebooks and was able to point me in the right direction and give me tips on how to implement them and use them effectively. Next, my colleague in the art and language arts department was able to provide some helpful feedback on spelling, grammar, punctuation and served as my go-to person for bouncing ideas off of. She has over twice as much teaching experience as me, and has seen it all, so to speak. She also provided some observations from her own classes regarding notetaking. I am blessed to teach her daughter in science class and advisory (study hall) as well, so her daughter served as my student perspective resource, as she was available to talk during study hall without my questions disrupting her daily work.

The other two members of my support team work outside my district. One of them, my sister-in-law, teaches first grade in my hometown, and offers a unique lower grade level perspective that my colleagues at school cannot. We spend a lot of time together, so she was a great source of emotional support as well. Finally, the fifth member of my support team is a friend from high school who recently left teaching but has an enormous understanding of technology. She is highly skilled in using Microsoft Word, Excel, and Powerpoint, and was always available to assist with any technical difficulties I had.

CONCEPTUAL FRAMEWORK

In preparation for my action research project, I reviewed several literature sources, ranging from former research papers to articles and books. I used the information gathered from these sources to help me design, conduct, and analyze the results from my research. I started by discussing some of the theoretical literature supporting and/or addressing this particular action research project. Next, I discussed the literature behind this notetaking technique (interactive notebooks). Finally, I addressed the literature pertaining to the data collection and analysis methods I used throughout my research.

Educational Theory

In the preface to her book on adolescent learning, Crawford (2007) states

> …adolescent learning is an active, emotional, and socially shared process of higher order knowledge building for understanding. The teacher becomes less directive as adolescents assume increasing responsibility for personal learning management (p. X).

At the middle school level, students are becoming more responsible for their own learning. Students are no longer given everything they need to know, but are instead given the basics, and are asked to build on those basics and make connections to achieve higher order knowledge. Students at the middle school level are asked to become more independent learners, no longer relying completely on teacher-led instruction. Crawford (2007) also states that "Teachers who teach with adolescent learning in mind do the following: …Find out what students know or remember and help them relate to new learning by building connections" (p. 3). It is therefore the teacher's job to help make content meaningful to students by helping them build bridges linking the content to their everyday lives. She also states that it is the teacher's role to "Give assignments that differentiate for students' varying learning needs" (Crawford, 2007, p. 4).

Teaching anybody, not only adolescents but students in general, requires the acknowledgement that every student is a unique individual with their own strengths, weaknesses, and needs. As teachers, we need to address those needs by providing multiple opportunities and multiple avenues through which students can successfully gain understanding. Often, this means we need to teach to a variety of learning styles.

According to a study by Bhagat et al. (2015),

> Learning styles (LSs) have been defined as the composite cognitive, affective, and physiological characteristics that are relatively stable indicators of how a learner perceives, interacts with and responds to the learning environment (p. S58).

They go on to discuss how there have been several tools developed over time to help us to understand how individual students learn. For example, they cited Neil Fleming's Visual, Aural, Read/Write, and Kinesthetic (VARK) questionnaire, describing how student learning preferences might fall under one or more of these four major categories.

> The quality of learning outcomes achieved is dependent to a considerable extent on the learning activities used by learners. These learning strategies can be broadly divided into self-regulated strategy in which the students perform most regulation activities themselves, externally regulated strategy in which the students let their learning process to be regulated by teachers/books or lack of regulation when students are unable to regulate their learning process by themselves and also experience insufficient support from external regulation as provided by teachers and learning environment (Bhagat et al., 2015, p. S59).

The same study noted that "recent research has made it fairly clear that different students have different LSs…However, individualization of instructional methods has not been shown to contribute significantly to learner outcomes" (Bhagat et al., 2015, p. S59). Although it is widely and commonly accepted that individual students have their own unique learning styles, whether it be auditory, visual, kinesthetic, etc., catering to each individual learning style has not necessarily had a great effect on learning outcomes, either positively or negatively. Bhagat et al. (2015) go on to claim that the "best" style is to apply a variety of teaching methods that can cater

to many different learning styles. This will enable all students to benefit and will also allow students to become more "flexible" in their learning styles.

Interactive Notebooks

Gilbert and Kotelman (2005) discuss, among many other reasons, five exceptional reasons for using science notebooks in the classroom. Their first reason was that notebooks are great thinking tools for students of any age. For example, after referring to a group of students that were observing and meeting snails for the first time, their teacher noted the following:

> As students eagerly wrote and drew in their notebooks, the teachers observed they were interacting more deeply with the subject matter. Many students had added their own questions on the topic that had not been charted by the whole class (Gilbert & Kotelman, 2005, p. 29).

Their second reason was that notebooks guide teacher instruction. Notebooks provide documentation for student thinking, understanding, and misconceptions, which can be used to guide and change instructional strategies, if needed. "The inclusion of visuals…taught students that information and ideas can be communicated in different ways and that some methods of communication are better suited for particular information" (Gilbert & Kotelman, 2005, p. 30). Another useful application for science notebooks is that they enhance literacy skills. "In some cases, teachers observed that students' ideas were clearer when they communicated through a combination of written and visual text" (Gilbert & Kotelman, 2005, p. 31). This ties back into the different learning styles; students can communicate more effectively if they are able to use styles that they are more comfortable with. A fourth reason for using science notebooks in the classroom is that notebooks support differentiated learning.

> Those students who were reluctant or less skilled writers often improved their explanations and descriptions when teachers engaged them with individualized feedback, which they often did on sticky notes right on the notebook pages. This ongoing interaction in the notebooks especially challenged higher-level students as

> teachers asked them increasingly more involved questions during their study. All in all, teachers commented throughout their study group sessions that they felt they could individualize in a unique way when they provided feedback over time in their students' notebooks (Gilbert & Kotelman, 2005, p. 31).

The final reason the authors mentioned for using science notebooks in the classroom is to foster teacher collaboration. The teachers in the study consistently provided feedback on what worked and what didn't work. Something that worked for one student might not have worked for another, and each teacher was able to share that information with the others. Several students may have observed the same phenomenon, but recorded entirely different data, all of which may be correct. For this reason, Gilbert and Kotelman (2005) stated "Both teachers and students came to realize there often is more than one right way to organize and express ideas" (p. 32). Again, this all ties back to the different learning styles individual and unique to each student.

After reading the previous article, the importance of effectively using a science notebook in the classroom is clear to see. However, just the presence of the notebook alone is not enough. There needs to be clear structure, organization, and consistency built into the science notebook to make it an effective tool for both students and teachers alike. The use of a notebook in science is nothing new. For many years, scientists have been using notebooks to record their ideas, ask questions, make observations, etc. "While a traditional science notebook only uses the right page, an interactive science notebook uses the left page to facilitate interactions between students and between the student and the teacher" (Mason & Bohl, 2017, p. 39). Teachers can pose pre-assessment questions at the start of a unit to assess prior knowledge and misconceptions. Students can then discuss their prior conceptions in small groups or as a class. The teacher can continue to assess the science notebook throughout the unit to address misunderstandings and to provide feedback on student ideas and thoughts. Students can actively record questions, thoughts, and new knowledge gained throughout the unit to develop a timeline of progression.

The authors note that interactive notebooks can work as a very valuable assessment tool, whether formative or summative. Mason and Bohl (2017) shared "although the notebooks were graded, the science notebooks were even more beneficial as a formative assessment tool to gather information about student thinking" (p. 40).

Mason and Bohl (2017) discuss a particular teacher's use of interactive notebooks at the beginning of the year to introduce science, the science and engineering practices, and the cross-cutting concepts of the Next Generation Science Standards. Students were asked to define science, draw their ideal version of a scientist, and describe what scientists do. Students then discussed their responses with the class, and with the teacher, they further refined their definition of science.

> Each experience engaged students in asking questions, building vocabulary, recording observations, and drawing conclusions. In the role of scientists, they took maintaining their notebooks very seriously because they were authoring a book that was "written and illustrated by" them, and their name was on the cover (Mason & Bohl, 2017, p. 42).

According to this article, making the science notebook more personalized and interactive is a great way to make sure the note-taking process is meaningful to students and to help students become more engaged and excited about taking notes.

According to Cheryl Waldman and Kent Crippen (2009), "at its best, an interactive notebook provides a varied set of strategies to create a personal, organized, and documented learning record….interactive notebooks empower students for science achievement" (p. 51). I wanted to collect data that supports this very idea: students will reach higher achievement and deeper content knowledge with the use of an interactive notebook. This article explains the general structure of the interactive notebook, including "in," "out," and "through" activities. The "in" activities are usually either review of previous content or preview of upcoming content and

are prompted by student responses. The "through" activities, however, are provided by the teacher. The through activities "…can include conducting lecture or discussion, engaging in a laboratory procedure, viewing a film/documentary…" (Waldman & Crippen, 2009, p. 52). The through activities result in an "input" of information from the teacher to the students. The "out" activities act much like an exit ticket and can include a summary or review of the day's concepts. Like the "in" activities, these "out" activities are teacher initiated, but student directed, and include subjective information.

Waldman and Crippen (2009) explain that the "in" and "out" activities are placed on the left page, and the "through" activities are placed on the right. Among the chief goals of the "in" and "out" activities are engagement, assessment, emphasizing, and creating, all of which may involve a variety of different strategies.

> Our personal classroom research indicates that interactive notebooks contribute to learning; students perceive them as tools that positively impact their ability to learn science; and the notebook increases their ability to organize the materials associated with learning (Waldman & Crippen, 2009, p. 53).

At the conclusion of their study, the researchers compared student scores in their science notebooks to final course scores, and there was a positive correlation.

Methodology

In a study like my own proposed study (Johnson, 2013), the action research project spanned throughout four units, with two units receiving treatment, and two units receiving no treatment. At the start of the study, students were given a pre-treatment unit where the interactive notebook was introduced and the methods for maintaining the notebook were practiced. This allowed students to get used to the format and structure of the interactive

notebook. Each unit progressed through the 5E Learning Cycle (Engage, Explore, Explain, Expand, and Evaluate). The difference between the treatment and non-treatment group was the use of an interactive student notebook versus the use of a three-ring binder (standard notebook). The interactive notebook was more structured and organized using input and output pages. The researcher included "Reflect and Connect" pages as well as "Aha Connections" pages. These would fall into the output page, where students make connections to the input and discover new meaning and applications for the input. These two pages were the main distinguishing feature between the interactive notebook and the standard notebook.

Johnson (2013) collected a multitude of qualitative and quantitative data using several different instruments to effectively answer her main focus questions as well as her sub-questions through the triangulation method. Quantitative data included pre- and post-assessment scores, rubrics (for the notebook and the assessments), and formative assessments (Classroom Assessment Techniques). Qualitative data included data from the teacher journal, Likert-style student confidence surveys, student and/or focus group interviews, and notebook entries.

Young (2003) states the need to

> explain to the students early on that when the notebooks are reviewed, many things will be considered. These should include how complete the entries are and how much effort has been put into the writing, effort being completion and thoroughness (p. 46).

Students must understand that although every notebook will look different, and there isn't necessarily a wrong or right answer, there are certain components that are expected of everyone's interactive notebook. For example, not only do students need to include the input given from the teacher, but they also must show their effort to make their own connections to and applications for the input on the output pages. Young (2003) also states

> It is essential to check the students' notebooks often. A glance at the notebooks during class, and collection of them on the day of a unit test for a more detailed review, should provide sufficient evaluation (p. 46).

If the notebook isn't checked frequently and frequent feedback isn't given, students might fail to see the purpose in the interactive notebook. Students need to be held accountable on a regular basis for keeping up with their progress within their interactive notebook. After all, it cannot be considered interactive if the student and teacher are not both interacting within the notebook on a regular basis. In an article written by Ross (2006),

> the central finding of this review is that the strengths of self-assessment can be enhanced through training students how to assess their work and each of the weaknesses of the approach (including inflation of grades) can be reduced through teacher action, (p. 1).

Ross (2006) argues that

> …the benefits of self-assessment are more likely to accrue when three conditions are met: teacher and students negotiate self-assessment criteria, teacher-student dialogue focuses on evidence for judgements, and self-assessments contribute to a grade (by students alone or in collaboration with teachers, (p. 2).

Students are more likely to honestly assess their own work if they have a say in what their work will be assessed on. They are also likely to more accurately self-assess if they know that the assessment is based on tangible evidence and if the assessment contributes to a grade.

As the title of this article (Ross 2006) suggests, many concerns of self-assessment revolve around the reliability of this assessment technique. What does it mean for an assessment to be reliable and how do we know if or when an assessment is reliable? "Reliability, meaning the consistency of the scores produced by a measurement tool, can be determined in many ways. The internal consistency of self-assessments is typically high" (Ross, 2006, p. 2). Ross goes on to explain that self-assessment is not only consistent within one task, but over several different tasks as well. However, it was found that consistency isn't as high across different time periods. The longer the time periods, the less consistent the self-assessments. The important part to note

is that "the studies showing adequate consistency involved students who had been trained in how to evaluate their work" (Ross, 2006, p. 3). Again, the importance of showing students how to evaluate themselves is just as important, if not more-so, than the evaluation itself.

Another common concern regarding self-assessment is validity.

> Validity in self-assessment typically means agreement with teacher judgements (considered to be the gold standard) or peer rankings (usually the mean of multiple judges which tend to be more accurate than the results from a single judge). Research on the self-assessments of university students produced mixed results. (Ross, 2006, p. 3).

Ross (2006) goes on to report that "student self-assessments are generally higher than teacher ratings," and "agreement of self-assessment with peer judgements is generally higher than self-teacher agreement" (p. 3). However, he attributes this difference to the different interpretation of criteria by students versus teachers.

Just as any form of assessment has both strengths and weaknesses, so does self-assessment. Of the many strengths of self-assessment that the author mentions, a positive impact on student achievement and behavior is highlighted. Ross (2006) reported "there is ample evidence that self-assessment contributes to student achievement…There is also evidence that self-assessment contributes to improved student behavior" (p. 7). Some students prefer self-assessment to typical assessment by only the teacher. Many students enjoy being involved in setting the criteria for the self-assessment. Other students appreciate factors such as effort being included in the assessment process. Finally, many students seemed to appreciate the opportunity to communicate with the teacher their own thoughts regarding their work and effort.

Conclusion

After reviewing several literature sources pertaining to learning theory, notetaking, interactive notebooks, and methodology, I gained some very valuable information. I have

developed a deeper understanding of why, theoretically, an interactive notebook might be preferable to a standard notetaking technique. Interactive notebooks can essentially be beneficial to students across multiple learning styles. I have also gained some valuable insight into how an adolescent mind functions with a combination of experience, emotion, and intellect.

An interactive notebook can help address these needs unique to adolescent learners. It can also provide an easier path for individual differentiation to make the content more meaningful to each individual student. Students can make their own connections with the content, ask questions, propose solutions, and journal their own thoughts and experiences related to the topic at hand. In this way, an interactive notebook makes the science experience more personal.

Finally, I have gained valuable insight into some of the methodology that I used in my project. Specifically, I gained insight into how to assess the interactive notebook itself as the teacher, but also how to meaningfully allow students to self-assess their own work as well. This literature review also allowed me to see the importance of qualitative data as well, including data from student surveys, observation, and teacher journaling.

METHODOLOGY

Treatment

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (see Appendix A). Table 1 provides a general schedule and summary for the treatment and non-treatment units as well as the topics covered within each unit. Adjustments were made to the schedule as the year went on. The original plan was to have two treatment units and two non-treatment units at each grade level, for a total of four units at each grade level (eight units total). However, due to time limitations, planning complications, and unscheduled events, I decided to complete two units at each grade level instead for a total of four units. Non-treatment units consisted of standard notetaking techniques, whereas treatment units consisted of implementation of interactive notebooks, as described below.

Table 1. Treatment and non-treatment unit summary.

Dates	Grade Level &Topic	Treatment vs. Non-Treatment
9/25-12/3	7th Grade: Interactions of Life (Ecosystems) 8th Grade: Exploring Earth (Earth's Structure) Standard Notetaking Techniques: • Outlining • Vocabulary • Main ideas • Cornell notes	Non-Treatment Instruments 1.) Notetaking Survey 2.) Learning Style Questionnaire 3.) Pre-Assessments 4.) Observations 5.) Student Self Assessment Notebook Rubric 6.) Teacher Assessment Notebook Rubric 7.) Post Assessments
12/6-2/18	7th Grade: Life Structure and Function 8th Grade: Geologic Changes • Interactive Notetaking • Input and Output • Right and Left pages	Treatment Instruments 1.) Notetaking-Survey 2.) Learning Style Questionnaire 3.) Pre-Assessments 4.) Observations 5.) Student Self Assessment Notebook Rubric 6.) Teacher Assessment Notebook Rubric Post Assessments

During the first unit of the year, students completed notes independently using their own preferred format (outlining, vocabulary, main ideas, Cornell notes, etc.). Some notes were provided by the teacher, but students were responsible for recording notes in their notebooks in whatever manner they chose. Prior to the non-treatment unit, students at both grade levels completed a notetaking survey (Appendix B) and a learning style inventory questionnaire (Appendix C). Seventh grade life science classes were assessed prior to and at the conclusion of the non-treatment unit using an Ecosystems unit pre/post assessment (Appendix D), while eighth

grade earth science students were assessed prior to and at the conclusion of the non-treatment unit using the Earth's Structure unit pre/post assessment (Appendix E). Teacher observations were noted throughout the unit at both grade levels using a journal. At the conclusion of the non-treatment unit, all students filled out the student self-assessment science notebook rubric (Appendix F) and received a teacher score using the same rubric.

At the start of the treatment unit, students received direct instruction on setting up their interactive notebooks. They were instructed that the right-hand pages were for teacher-provided materials that would often be completed together as a group, whereas the left-hand pages were to be left for their questions, comments, and "interaction" with the provided material. As a class, we reviewed the science notebook rubric (Appendix F), so students were reminded of the expectations. Prior to and at the conclusion of the treatment unit, seventh grade students were assessed using the Structure and Function of Life pre/post assessment (Appendix G) while eighth grade students were assessed using the Geologic Changes pre/post assessment (Appendix H). Throughout the treatment unit, teacher observations were noted in a journal. At the conclusion of the treatment unit, students filled out the note-taking survey a second time and once again completed an interactive notebook self-assessment. I then assessed their notebooks using the same rubric.

Demographics

Data was collected in all six of my science classes, three of which were seventh grade life science and three of which were eighth grade earth science. Although my class sizes fluctuated throughout the two units, 130 students participated and provided data (N=130). In this project, I separated the data by grade level, as students were learning different content at the different

grade levels. I was also curious to know if there would be any significant differences between the results at each grade level. Havre Middle School had a student population of approximately 400 students ranging from grades six to eight, including a minority enrollment of 31%. 49% of the student population were economically disadvantaged. Approximately five students were English language learners.

There were 67 seventh graders in all (*n*=67), comprised of 31 females and 36 males. There were 11 active Individualized Education Programs (IEPs) and two active 504 Plans in this sample at the time of the study. The seventh grade sample was composed of the following races and ethnicities: 54 White students, 11 American Indian or Alaska Native students, two students of two or more races. Of these students, three were parent identified as Hispanic/Latino.

There were 63 eighth grade students in all (*n*=63), with 32 females and 31 males. There were four active IEPs and three active 504s in this sample at the time of the study. The eighth grade sample was composed of the following races and ethnicities: 50 White students, eight American Indian or Alaska Native students, one Black or African American student, four students of two or more races. Of these students, four were parent identified as Hispanic/Latino. At the time of this study, data regarding number of students receiving free and reduced lunches was unavailable. However, the number of approximately 49 percent of students were considered economically disadvantaged.

Data Collection and Analysis Strategies

The Notetaking survey (Appendix B) consisted of 15 questions: ten Likert-style questions and five explanation questions. The survey was designed to measure student attitudes towards taking notes and the usefulness of notes inside and outside the classroom. Scores on the survey could range from 0-40, with lower scores corresponding to more of a negative attitude towards notes and notetaking and higher scores corresponding to more of a positive attitude towards notes and note taking.

The Learning Style Inventory Questionnaire (Appendix C) was developed by Jonelle Beatrice (1994). The questionnaire contained 14 multiple choice questions pertaining to students' preferred methods of learning. The questions consisted of three response options for learning modalities: visual, auditory, and kinesthetic. This instrument was designed to determine each student's preferred learning modality.

The science notebook rubric (Appendix F) was initially developed by Ellsworth (2015) and was modified for use in this specific research project. The same rubric was used for both the treatment and non-treatment units as a student self-assessment and as a teacher's assessment. Although the rubrics were the same, the content and setup of the treatment and non-treatment units were different. The non-treatment rubric assessed students' personal preferred note-taking techniques and strategies, whereas the treatment rubric assessed students' interactive notebook strategies.

The pre- and post-assessments for both grade levels during both units (see Appendices D, E, G, and H) consisted of multiple-choice questions related to each specific content area. The pre and post assessments were the same for each unit, for a total of four different assessments (two at each grade level, one for the treatment unit and one for the non-treatment unit). Table 2 summarizes the research questions and the instruments used to collect data pertaining to each

question. The type of data is also included (qualitative or quantitative). Qualitative data came from the teacher journal, observations, and student survey/questionnaires. Quantitative data came from each instrument.

Table 2. Data collection triangulation matrix.

DATA COLLECTION MATRIX (QL = QUALITATIVE DATA QT = QUANTITATIVE DATA)	TEACHER JOURNAL	OBSERVATIONS	PRE AND POST ASSESSMENT	STUDENT SURVEYS	RUBRIC	SELF-ASSESS
RESEARCH QUESTIONS						
Main Topic What is the effect of interactive notebooks on student content knowledge and achievement?			QT		QT	QT
Sub-question #1 ❖ Are students more engaged in notetaking when using interactive notebooks as compared to standard note-taking techniques?	BOTH	BOTH		QL		
Sub-question #2 ❖ Are students more likely to use interactive notebooks than regular notebooks outside of class, for the purposes of studying, completing assignments, and reviewing?	QL	BOTH		BOTH		
Sub-question #3 ❖ Are interactive notebooks more effective at meeting the needs of multiple learning styles than standard notebooks?	QL	QL		QL		

To help ensure the validity and reliability of my instruments, I chose to sample two different grade levels. This allowed me to not only compare data from two different age groups/maturity levels, but also to compare data from different content areas. My sample sizes at each grade

level were above 60 (seventh grade *n*=67 and eighth grade *n*=63), and this allowed for more accurate data and analysis. Pre-assessments and post-assessments for each unit were the same, allowing me to accurately analyze positive or negative changes in content knowledge. In addition to large sample sizes at different grade levels, validity and reliability was also enhanced by using published and vetted instruments such as the Learning Style Inventory (Appendix C) and the Science Notebook Rubric (Appendix F). Finally, each of my research questions (the main question and sub-questions) were addressed via the triangulation method by using at least three different instruments. Using these instruments, a variety of quantitative and qualitative data was collected.

DATA AND ANALYSIS

Results

At the start of the study as well as at the conclusion, students were given the Notetaking Likert Survey (see Appendix B) to determine overall student attitudes and thoughts towards their own notetaking abilities as well as the usefulness of notetaking both during class and outside of class. The results of the seventh grade Likert Survey are listed below with analysis to follow.

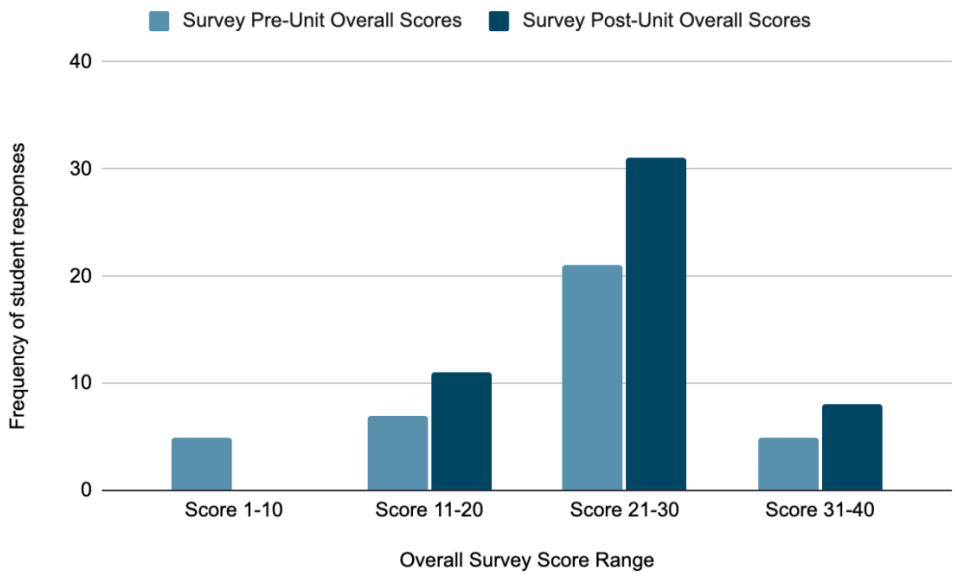

Figure 1. Seventh grade note taking Likert survey pre-unit and post-unit results, (*n*=50).

Scores ranging from zero to ten indicate an overall negative attitude or lower confidence towards notetaking and its usefulness. Those scores ranging from 11-20 indicate a slightly negative or neutral confidence/attitude level. Scores of 21 to 30 indicate an overall neutral to slightly positive attitude towards notetaking and its usefulness. Finally, scores ranging from 31 to 40 indicate an overall positive attitude and higher confidence in notetaking and its usefulness. Scores within the middle ranges (11-30) don't necessarily mean students have more of a positive

or negative attitude but may just indicate they don't have a strong preference either way. Scores falling within one to ten do indicate an overall lower confidence level and/or more negative attitude. Scores 31-40 indicate an overall higher confidence level and/or more positive attitude. The average "score" on the initial survey at the start of the study was 24, falling within the neutral-positive range. Of all seventh-grade respondents, 13 percent scored in the overall negative range, 19 percent fell within the negative-neutral range, 55 percent fell within the neutral-positive range, and13 percent fell within overall positive range.

At the end of the study, the average "score" was 25, again falling within the neutral-positive range. Of all seventh-grade respondents, 0 percent scored in the overall negative range, 22 percent scored in the negative-neutral range, 62 percent scored within the neutral-positive range, and 16 percent scored in the overall positive range. From the graph, it appears that the overall student attitude and student confidence in notetaking increased. By the end of the study, there were no respondents that fell within the one to ten (overall negative) range. I interpreted this to mean that students gained more confidence in their notetaking abilities as well as found the notes more helpful and useful overall.

Table 3 below illustrates the frequency of student responses relating specifically to the usefulness of notes inside and outside of the classroom. There were more student responses on survey two (n=54) than on survey one (n=34).

Table 3. Frequency of 7th grade student attitudes, (*n*=54).

	0 (Strongly Disagree)	1 (Disagree)	2 (Neutral)	3 (Agree)	4 (Strongly Agree)
Useful In Class (start)	0	0	1	17	16
Useful Outside of Class (start)	1	7	9	10	7
Useful In Class (end)	0	0	5	22	27
Useful Outside Class (end)	4	8	20	14	7

On the initial survey thirty three of the thirty-four respondents (97 percent) either agreed or strongly agreed that notes are a useful tool for them to use during class. One student stated, "They help for when I need to look back at something I forgot." Another student stated "There is a lot of information that you need to know. Notes can help you remember what you need to know. It isn't always easy to remember something amidst all of the other knowledge." A third student stated, "Notes help me concentrate and if I get what I'm writing notes about, it helps me understand it better." The qualitative and quantitative data suggest to me that most of my students find the notes themselves as a helpful tool to refer to throughout the unit, specifically to help them recall information.

On the other hand, although many students still had an overall positive attitude of the usefulness of notes outside of class, most results were spread closer to the neutral attitude.

Seventeen respondents (50 percent) either agreed or strongly agreed that notes are a useful tool outside of class. Nine students (26 percent) of students felt neutral about the usefulness of notes outside of class, and eight students (24 percent) either disagreed or strongly disagreed that notes are useful outside of class. One student stated, "I only use notes for class." Another student stated, "I never have time to look over them." A third student wondered "Why would you need them outside of class?" The qualitative and quantitative data related to this question suggest to me that although many students still use their notes outside of class, they don't necessarily find them as helpful or don't necessarily know how, why, or when to use them outside of class time.

On the final survey, more students responded, providing more qualitative and quantitative data. Approximately 91 percent of students either agreed or strongly agreed that notes are a useful tool in class. One student noted. "I believe notes are a useful tool in class because it refreshes your brain on tools you learned but kind of forgot about. They also include details that you brain might be leaving out on." Another student noted that "Notes are a great study tool and a fun reference if you did it right."

Like survey one, there were more students that responded closer to the neutral-negative range on the question relating to the usefulness of notes outside of class. Approximately 40 percent of respondents either agreed or strongly agreed that notes are a useful tool outside of class. This data shows that students found notes less useful outside of class at the end of the unit than they did at the beginning. One respondent stated, "There's no reason for me to look at notes outside of class because we will talk about it the next day." Another student noted "I don't really study a bunch because I normally remember the stuff we talked about." Another student was applying the usefulness of notes outside of school altogether, stating that "For the job I want, they're not going to ask me about moon phases." This particular response brought to light an interesting thought

that maybe some students really didn't understand how notes can be used outside of the classroom, but still for classroom purposes. It also made me think I should have attached a question or two related to life skills, jobs, etc. and the usefulness of taking notes in a job or career setting.

To summarize, although it appears students overall gained a more positive attitude about notes/note taking through the study, it also became apparent that students don't necessarily recognize the potential usefulness of notes or note-taking outside of the classroom. I also noticed that many students considered tests and studying for tests the primary benefit of taking notes in the first place. This was true both prior to the treatment and after the treatment.

To determine the effect of interactive notebooks on student content knowledge and achievement, I chose to calculate the normalized gain, which is essentially how much students have learned as compared to how much students could have learned. Figure 2 illustrates the seventh-grade average scores on both pre-assessments and post assessments, for both the non-treatment and treatment units. The non-treatment unit consisted of content related to ecosystems, whereas the treatment unit consisted of content related to cells and the structure and function of life. Average scores for the non-treatment unit were 61% (pre-assessment) and 76% (post-assessment. Average scores for the treatment unit were 51% (pre-assessment) and 61% (post-assessment).

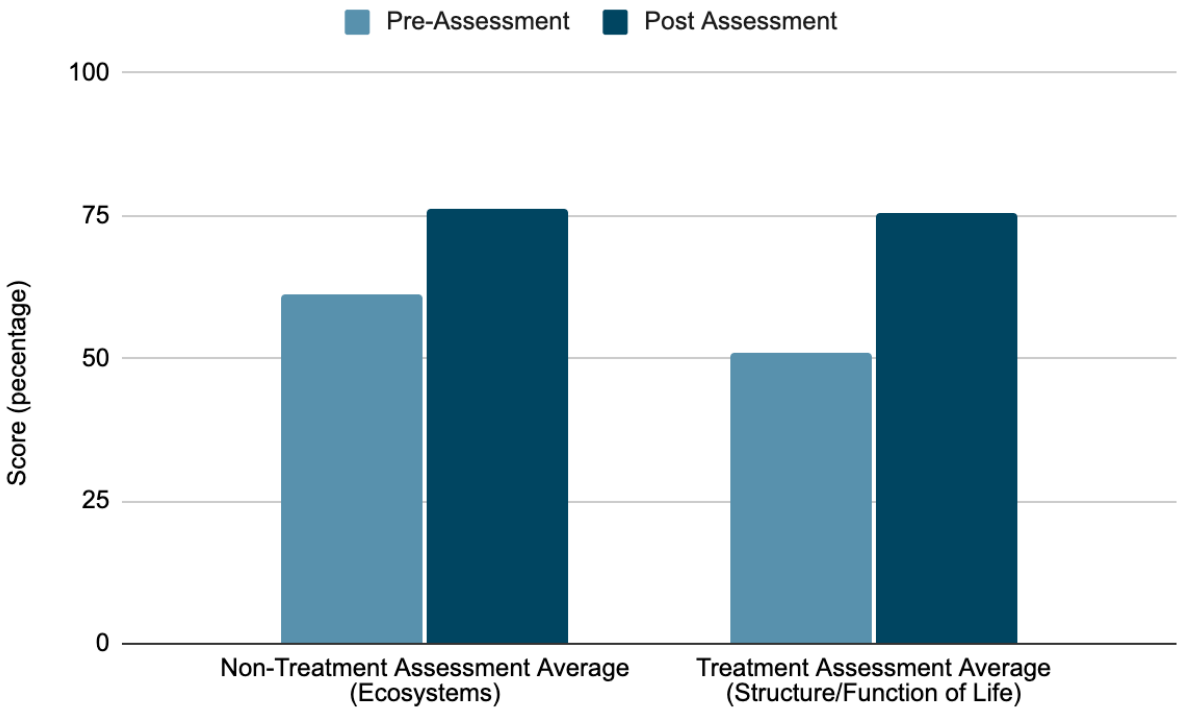

Figure 2. 7th Grade average scores pre and post assessment treatment vs. non-treatment, (*n*=67).

As can be seen in the graph (Figure 2), students, on average, scored higher on non-treatment unit assessments. However, they made a larger gain between pre-assessment and post-assessment during the treatment unit. Both the treatment and non-treatment groups showed a positive normalized gain, with the non-treatment unit at a normalized gain of .38 and the treatment unit at a normalized gain of .49. In other words, students, on averaged, gained 38% of what they could have gained between pre and post assessment over the non-treatment unit and gained 49% of what they could have gained between pre and post assessment over the treatment unit. The normalized gain was larger for the treatment unit than it was for the non-treatment unit.

Another tool that was used to determine the effect of interactive notebooks on student content knowledge/achievement was the science notebook rubric (see Appendix F). The same rubric was used by the students to assess themselves and for me to assess them as well. I found

that most of the students were harder on themselves than I was in terms of grading. Many of the students gave themselves a lower score than what they deserved. However, most of the scores were within five to ten points (out of a total of 50) so I would have to say many students were honest and straightforward in their self-assessments of their notebooks. I noted this to be true of both the non-treatment unit (standard notetaking) and the treatment unit (interactive notebooks). During both units, the most common struggle was with order and organization. I found that many of the pages were complete but were scattered about randomly throughout the notebook in no particular order, making it difficult for both the students and I to track the pages down and assess them. In the treatment unit, many of my student struggled to maintain the output pages. The input/output pages weren't always in the correct spots (right vs. left) and students didn't always interact with their notebooks on their own the way I had hoped. This may be due to students' lack of previous exposure to interactive notebooks or perhaps my own lack of explanation and instruction in the importance of the interaction. Another possibility is that students at this point are uncertain of what "interacting" with their notebook means. Students might need more practice formulating questions and observations, and noticing patterns, etc. Perhaps students have not specifically been taught how to ask sound scientific questions or how to make relevant observations. On a positive note, there were no zeros given out, as all of the students completed at least portions of their notes throughout both units.

Of the 67 seventh grade students included in this study, 33 of them (n=33) participated in the Learning Style Inventory Questionnaire (see Appendix C). The results are included in Figure 3 below. Most students who participated (22 students or 67%) would be considered visual

learners, followed by 4 students (12%) auditory learners, 4 students (12%) multiple learning styles, and the fewest number of students 3 (9%) would be considered kinesthetic learners.

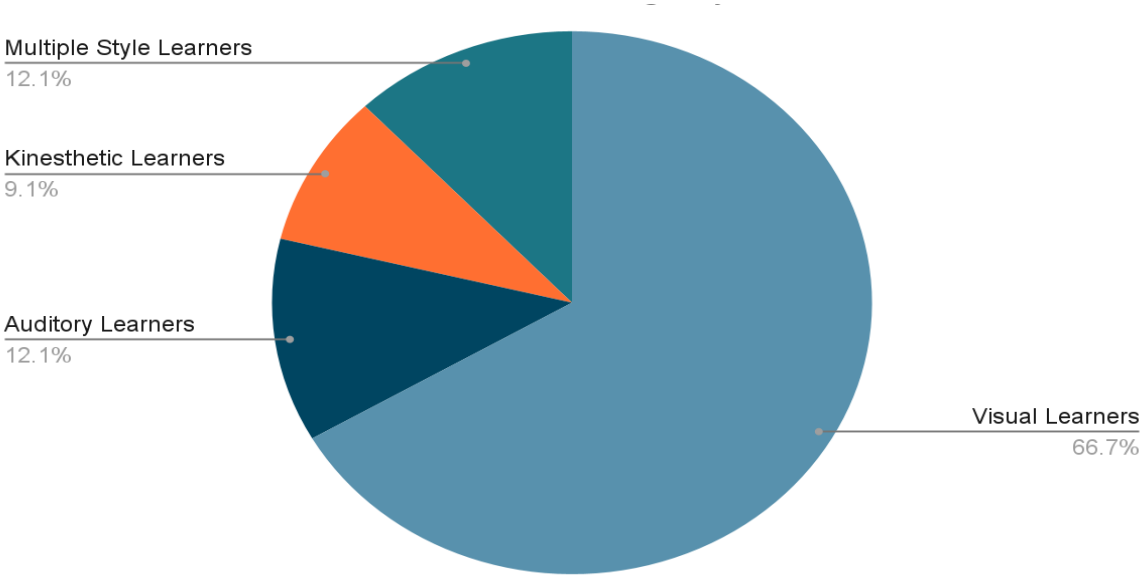

Figure 3. Summary of 7th grade student learning styles, (*n*=33).

According to the questionnaire developed by J.A. Beatrice (1994), visual learners "use neatly organized or typed material," "use notepads, post-Its, to-do lists, and other forms of reminders," and "develop written or pictorial outlines of responses before answering essay questions." Beatrice (1994) stated that auditory learners "rehearse information orally," "use mnemonics, rhymes, jingles, and auditory repetition through tape recording to improve memory," and "read your notes aloud." The questionnaire also states that kinesthetic learners "use all of your senses-sight, touch, taste, smell, hearing," "use practice, play acting, and modeling to prepare for tests," and "use direct involvement, physical manipulation, imagery, and 'hands on' activities to improve motivation, interest, and memory."

After receiving the results of both note-taking surveys, as well as the pre and post assessment scores, it is clear to me that visual learners seemed to have a more positive attitude

and confidence in their note-taking abilities. When I compared the type of learners to their results on the notetaking survey, there didn't appear to be a strong correlation between auditory, kinesthetic, or multiple learning modalities and their attitudes/confidence towards note-taking. However, this might have been because there were only a small number of students (11 total) that were not considered primarily visual learners. However, I did notice that many of the other types of learners did tend to respond within or near the neutral range on the notetaking survey. Students that fell within auditory, kinesthetic, and multiple learning modalities, on average, had lower scores on their science notebook rubric then their visual learning peers. This was true in both the treatment and the non-treatment units.

At the start and conclusion of the study, eighth graders were given the same note-taking survey as the seventh grade (Appendix B). A summary of the scores on the Likert survey is included in Figure 4 below.

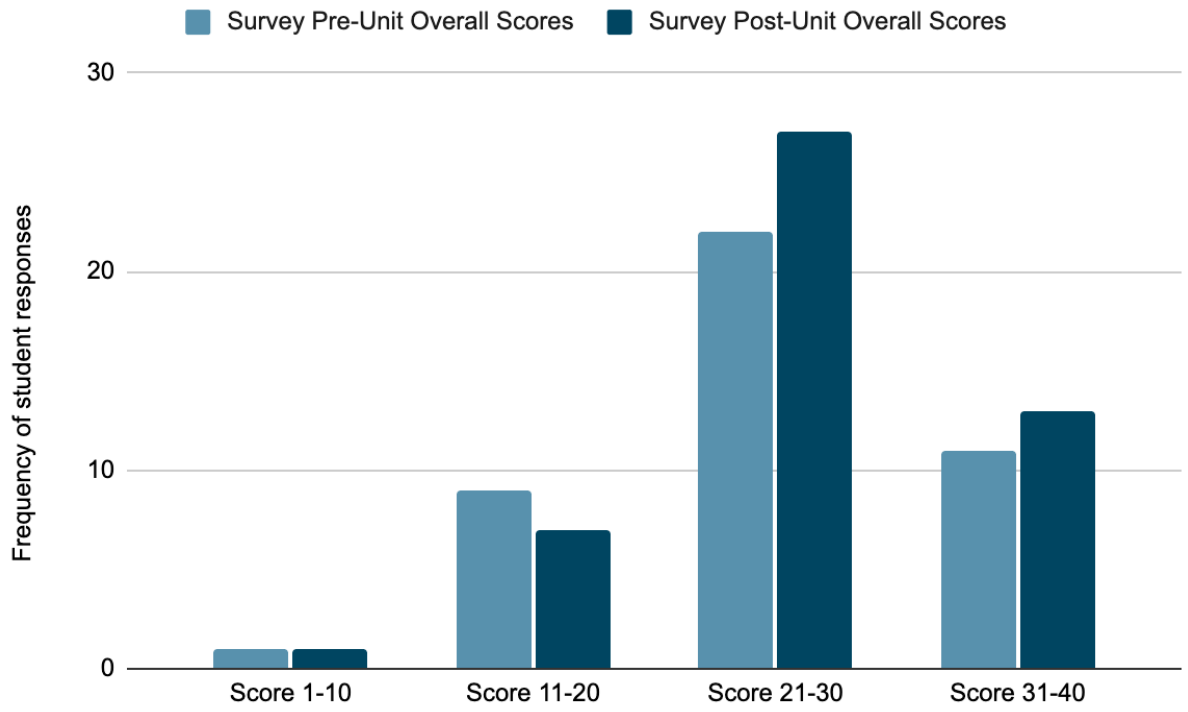

Figure 4. Eighth grade note taking Likert survey pre-unit and post-unit results, (*n*=48).

Like the results from the seventh grade survey, looking at the graph (Figure 4) it appears that overall attitudes/confidence in student notetaking has slightly increased. There are more student responses in the overall positive and neutral-positive ranges from the end of study survey than the start of study survey.

The average "score" of the initial survey was 25, which falls within the neutral-positive range. Two percent of eighth graders scored in the overall negative range, 21 percent scored in the negative-neutral range, 51 percent scored within the neutral-positive range, and 26 percent scored within the overall positive range.

The average "score" of the final survey was 26, which also falls within the neutral-positive range. Two percent again scored within the overall negative range, 15 percent scored within the negative-neutral range, 56 percent scored within the neutral-positive range, and 27 percent scored within the overall positive range. Just like the seventh-grade scores, the average went up by one point and as the graph shows, there were more students in the more positive ranges than the more negative ranges at the end of the study than at the start. Although this isn't a huge difference, it still shows that there was a change in student attitude/confidence overall between the start and the end of the entire study.

Table 3 below illustrates the frequency of student responses relating specifically to the usefulness of notes inside and outside of the classroom. There were more student responses on survey two (*n*=56) than on survey one (*n*=47).

Table 4. Frequency of 8th grade student attitudes, (*n*=54).

	0 (Strongly Disagree)	1 (Disagree)	2 (Neutral)	3 (Agree)	4 (Strongly Agree)
Useful In Class (start)	0	1	3	14	29
Useful Outside of Class (start)	4	7	12	12	12
Useful In Class (end)	0	2	3	16	34
Useful Outside Class (end)	2	6	21	21	6

On the initial survey, 91 percent of student agreed or strongly agreed that notes are a useful tool in class. One student noted, "Notes give you a chance to review the knowledge you've gained so you can remember it for tests. It's just nicer to know scientific things and be able to remember them." Another student stated, "Notes are a very useful tool because it gives you something to use when you are stuck on an assignment or something you can use if allowed in a test." Once again, both quantitative and qualitative data shows that most students find notes very useful in class. However, on survey two, only 89 % of respondents agreed/strongly agreed that notes are helpful in class, so the positive responses decreased slightly. Also, like the seventh-grade results, students seemed to be less confident in the usefulness of notes outside of the classroom, as evidence by the increasing number of responses in the disagree/strongly disagree columns in Figure 4.

Once again, to determine the effect of interactive notebooks on my eighth-grade students' content knowledge and achievement, I again calculated the normalized gains for the average scores on the pre and post assessments. Average scores are summarized in Figure 5 below.

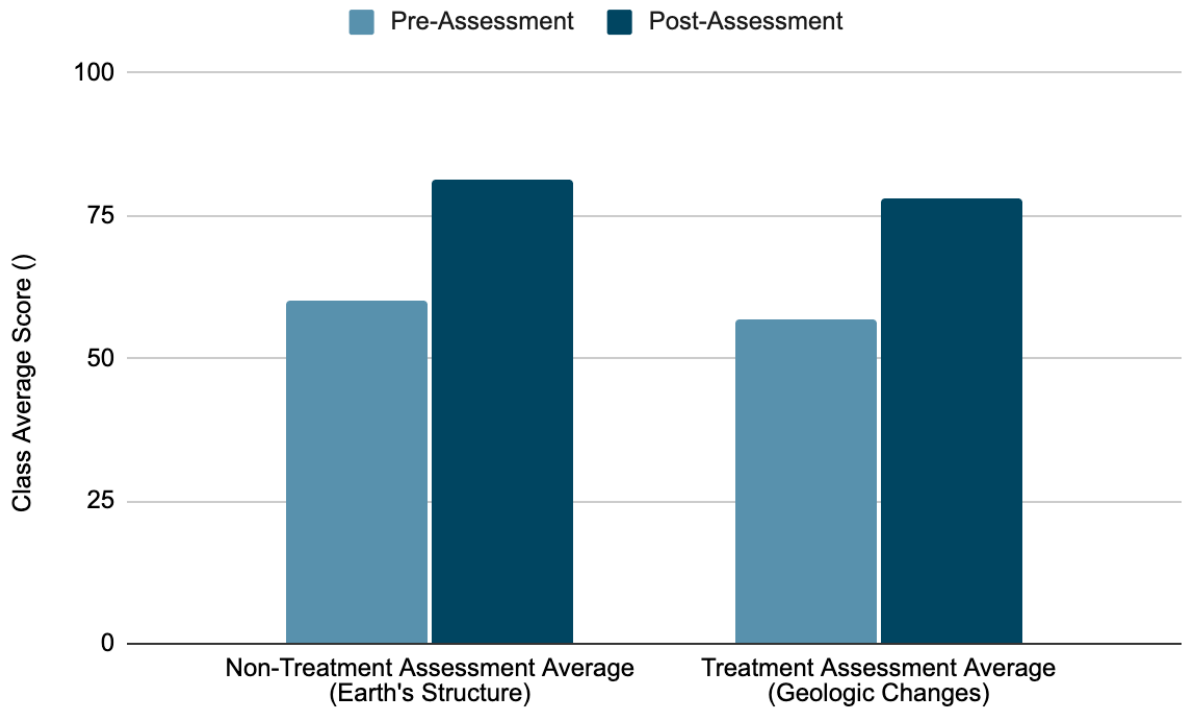

Figure 5. 8th Grade pre and post assessment scores, (*n*=63).

Like the seventh graders, the eighth graders scored higher on the non-treatment unit assessments. However, on average, they scored significantly better on the post assessments than on the pre-assessments. I again calculated the normalized gain for each unit. For the non-treatment unit, the class average normalized gain was .53 (53%). For the treatment unit, the class average normalized gain was .49 (49%). In this case, on average, the students gained less compared to what they could have in the treatment unit than in the non-treatment unit. However, unlike the seventh-grade data, the normalized gains for both units were close. According to this data, students on average did better in the non-treatment unit than in the treatment unit.

The results of the student notebook rubric were really similar to the results in my seventh grade. Students' self-assessment scores were s rather similar to the scores that I assigned, and many students even underestimated their notetaking abilities quite frequently. The only difference I noticed was that the eighth graders tended to have more organization. Their notes weren't randomly scattered about their notebooks, and they tended to include more titles and a variety of methods for organization, such as underlighting, highlighting, etc. This was observed much more often in the eighth grade notebooks than in the seventh grade notebooks.

Finally, eighth grade students took the Learning Style Inventory Questionnaire (Appendix C). The results are shown in Figure 6 below.

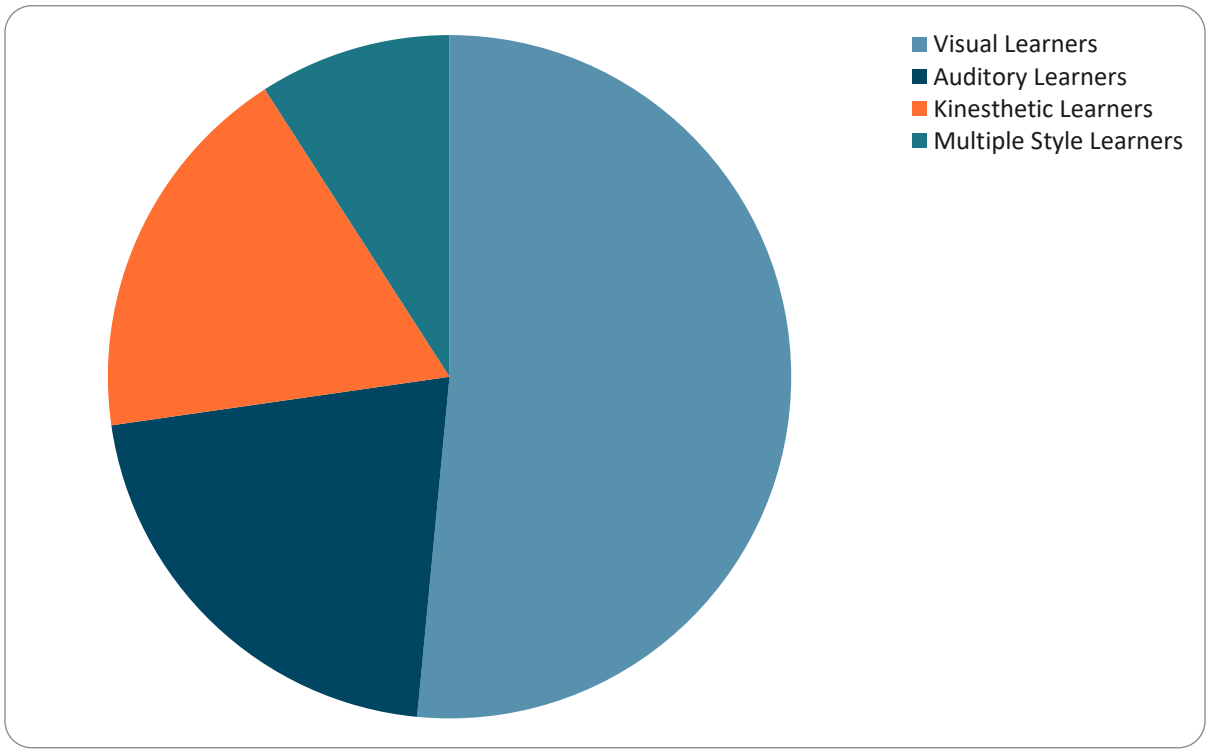

Figure 6. Summary of 8th grade student learning styles, (*n*=33).

As shown, 50 percent (17) of the eighth grade respondents were considered visual learners, which is significantly less than that of the seventh grade. 20 percent (seven) were considered

auditory learners, 17% (six) were considered kinesthetic learners, and 11 percent (4) were considered to have multiple learning modalities. Similar to the seventh grade, visual learners make up the majority of the class. Even though the ratio of the other learning styles relative to each other is about the same (close to equal parts auditory, kinesthetic, and multiple), there appears to be more of these types of learners in my eighth-grade classes than in my seventh grade. Once again, there didn't appear to be a clear correlation between the type of learner and the student's attitude/confidence in notetaking abilities. There were more than one of each type of learner that scored in each region of the note-taking survey. The visual learners, overall, did tend to score higher on the assessments in both units, but this isn't necessarily due to the type of notetaking.

CLAIM EVIDENCE AND REASONING

Claims From the Study

In conclusion, this action research project has taught me several lessons, some of which are related to my original focus questions and sub-questions, and some of which are not. My original research question is as follows: what effect do interactive notebooks have on student content knowledge and achievement in my science classroom? The data from this project provides several answers to this question. Note-taking in general helps to build upon and enhance prior knowledge. As one student stated, "They help refresh my memory." Another student stated, "They can help you remember information in an organized way." It helps students to remember what they have been taught, provides ample material for review, and acts as a way for students to visualize/personalize the content. The student descriptions provided as qualitative data from the note-taking survey show that notes themselves help to build content knowledge. The part that isn't so clear from the data is to what extent the interactive portion of the notetaking (the treatment unit) had on student content knowledge and achievement.

The seventh grade normalized gains showed that their content knowledge improved in the treatment unit as compared to the non-treatment unit. However, the qualitative/quantitative data gathered from observation and from the notebook assessment rubrics showed that the seventh-grade students had a harder time with the interactive portion altogether. Was it the interactive notebook that helped them succeed or was it simply the fact that their note-taking skills overall had improved over the course of a semester? On the other hand, the eighth grade data shows that the eighth graders didn't gain as much content knowledge in the treatment unit as they did in the non-treatment unit. Does this mean the interactive notebooks weren't successful? Could it also

be that the content itself was more difficult? Many of the eighth graders, like the seventh graders, also struggled to find ways to "interact" with their notebooks in their own way.

My first sub-question was are students more engaged in taking notes when using interactive notebooks as compared to standard note-taking techniques? This question was answered mainly through observations and informal teacher journaling. Throughout this action research project, it occurred to me that most students either love notes or hate them. Even the students that love taking notes and have twenty different colors and highlighters and sticky notes can only stay focused on one process for a given amount of time. Interestingly, one student noted "I don't hate taking notes, but they take up a lot of time because I always try to make them perfect and if it isn't to my liking, I redo them till they are." Through my observations, I did notice at least a handful of students who were very concerned with the organization/detail and perfection of their notes. This sometimes led to frustration. Another student stated, "I don't like notes that much because they are time consuming, confusing, difficult, and I usually end up not needing it anyways." On the other hand, students that enjoyed taking notes stated, "It gives me time to practice handwriting and helps me study about what we are learning." Another student that enjoyed notes stated, "I like taking notes because it is organized and very simple." I found it interesting that there were at least two students that noted that their enjoyment of notetaking depended on the day and what kind of mood they were in. It didn't appear to matter whether they were copying vocabulary from a book or asking questions or noting what they already knew about a given upcoming topic, their interest faded eventually, no matter what. My observations and some of the comments from the note-taking survey showed that for the most part, the interactive notebook wasn't necessarily any more or less engaging than other standard notetaking techniques.

Sub-question two: are students more likely to use interactive notebooks than standard notebooks outside of class for the purposes of studying, completing assignments, and reviewing? After viewing the results of the notetaking survey, and informally interviewing some students, became very clear to me that most students don't actually do much with their science notebooks outside of my classroom. Some of the explanation response from students showed me that students don't understand why they would want or need their science notebooks outside of my classroom. Although there were a few more students that agreed that science notebooks can be useful outside of the class by the end of the study than there were at the start of the study. However, the top three reasons students reported for using them outside of the classroom are for studying, completing homework, and reviewing. In the future, my goal would be to extend this so that students see their interactive notebook as more of a journal that they write questions/thoughts/ideas/hypothesis down in as they think of them.

My third and final sub-question: are interactive notebooks more effective at meeting the needs of multiple learning styles than standard notebooks?" Based on the quantitative and qualitative data I received, I don't think I can accurately answer that question. The results of my Student Learning Style Inventory/Questionnaire show that the majority of my students are visual learners, meaning they learn better by seeing. A lot of the work in most classrooms caters to the needs of visual learners, so it's not hard to see why they tend to be more successful in the classroom. However, as far as attitudes towards note taking and notetaking skills go, I didn't notice a significant difference between visual, auditory, kinesthetic, or multiple style learners. There seemed to be an array of all types of learners that fell into each category in the note-taking survey, and an array of learners receiving different scores on the assessments as well. I don't

think I have enough data to be able to say that interactive notebooks meet the needs of all types of learners.

Value of the Study and Consideration for Future Research

In addition to the questions directly related to my focus question and sub-questions, I also discovered some very useful facts about my students, myself and my teaching methods, and note-taking in general. Although I do believe that if implemented and assessed consistently and correctly, interactive notebooks have the potential to be more engaging and useful than standard notebooks, at this point, I need to figure out a way to help my students be more organized and efficient note-takers. One student stated, "Some notes in science could be fun and some other notes in science could be hard/boring." I would be interested in finding out if it is specific content areas that the student finds more fun, or if it is different notetaking techniques (concept maps, flow charts, etc.) that the student finds fun. Another student that enjoyed notetaking commented "I answered it that way because sometimes notes are fun to take, for example while we were studying cells and we had to draw the cells we saw under the microscope, and the thing that made it more fun was I got to add some not needed details that ended up helping me on the test." The past couple of years have kind of been a disaster as far as time and attendance goes, and for this reason, students and teachers alike are a bit behind on what would normally be expected to be learned and taught at different grade levels. Much of this year was spent trying to catch students up and get them back on pace. Once that is accomplished, hopefully it will be easier to implement something such as the interactive notebook. This year was tough, as there were so many attendance issues that my students and I had a hard time staying on track with who was gone what day and who needed to make up which notes, etc. I do still believe and based on

my data the majority of my students do too, that notes are an integral part of the learning process, as evidenced by the responses in the student note-taking surveys (see Table 3 and Table 4).

Impact of Action Research on the Author

I would like to explore some more alternatives that might specifically meet the needs of my auditory/kinesthetic learners. Are there note-taking techniques designed specifically with these students in mind? Could I create audio versions of my notes for students to listen to as they write? Can students record their own audio notes? I noticed several responses from students in their surveys that they had learned note-taking techniques from their parents or other teachers, and that they use them in other classes as well. I don't want students to think note-taking is strictly academic. I want students to picture a mechanic scribbling parts down on a piece of paper, or a farmer/rancher scribbling income and expenses, or an accountant keeping track of records/tax exemptions. My end goal would be to help students utilize notetaking in multiple areas of their life, not just academic areas. For this reason, I would like to begin looking into journaling as another method to improve student engagement, as journaling might allow students to personalize the content and make it more meaningful to them. Overall, this project has become a valuable tool in helping me get into the minds of my students to figure out what they are thinking and what they find helpful/valuable or not. I plan to use the results of this study to help me build on my curriculum planning for next year in hopes to incorporate a more interactive/journaling style in my classes next year and the years beyond. As I mentioned earlier, my seventh-grade students appeared to benefit more from the interactive notebooks specifically. They also needed a bit more guidance and support, but overall seemed to be more successful using the interactive notebooks. For this reason, I plan to at least try the interactive approach

again next year in my seventh-grade classes as well. I also plan to refine the way I have my students set up their notebooks at the start of the year and will continue having my students complete self-assessments for their notes. The student self-assessments allowed the students to see for themselves what areas they were strong in and what areas they needed to improve upon. On the other hand, my eighth graders didn't seem to benefit as much from interactive notebooks compared to standard note taking techniques. They also didn't need as much structure, guidance, or support in their notetaking. For this reason, I will probably not use the interactive notebooks with my eighth graders, but instead will focus on other note-taking techniques that accommodate kinesthetic and auditory learners as well.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION

RE: Katey Barber IRB Application

BK Beiswanger, Kelly <kelly.beiswanger@montana.edu>
To: Katey Barber
Cc: Woolbaugh, Walter <walter.woolbaugh@montana.edu>

Mon 11/8/2021 9:46 AM

Dear Katey,

Thank you for your application. This email acknowledges receipt of the request for IRB Review and serves as the Approval Letter for your research. Your new **IRB Exempt Protocol # is KLB110821-EX.**

Study Title: **The Effects of Interactive Notebooks on Science Content Knowledge and Achievement in the Middle School Science Classroom.**

As the PI, it is your responsibility to facilitate subject understanding by informing subjects of all aspects of the project, providing an opportunity to ask questions, and describing risks and benefits of participation. Submit any new changes to the research protocol to the IRB via Amendment Form prior to implementing.

The research described in your submission is exempt from the requirement of additional review by the Institutional Review Board in accordance with 45 CFR 690.104(d). The specific paragraph which applies to your research is:

(1) Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Thank you,
Kelly Beiswanger

APPENDIX B

NOTE-TAKING SURVEY

Please note that participation in this survey is completely voluntary and participation or non-participation will not affect your grade or class standing in any way.

Directions: Read each statement and circle the option that best matches your current feelings/attitudes about your own notetaking in science class.

1.) I take notes on my own without the teacher asking/requiring me to.

Strongly Disagree Disagree Neutral Agree Strongly Agree

2.) I know how to take notes without guidance from the teacher.

Strongly Disagree Disagree Neutral Agree Strongly Agree

3.) If you agreed to question 2, where did you learn this?

4.) I enjoy taking notes in class whether it is assigned or not.

Strongly Disagree Disagree Neutral Agree Strongly Agree

5.) Please explain why you answered the way you did in question 4.

6.) I enjoy taking notes if the teacher provides them.

Strongly Disagree Disagree Neutral Agree Strongly Agree

7.) I enjoy taking notes even if the teacher does not provide them

Strongly Disagree Disagree Neutral Agree Strongly Agree

8.) I think notes are a useful tool in class.

9.) Please explain why you answered the way you did in question 8.

Strongly Disagree Disagree Neutral Agree Strongly Agree

10.) I think notes are a useful tool outside of class.

Strongly Disagree Disagree Neutral Agree Strongly Agree

11.) Please explain why you answered the way you did in question 10.

12.) I use my notes to help me study for quizzes and tests.

Strongly Disagree Disagree Neutral Agree Strongly Agree

13.) I use my notes to help me with my daily assignments.

Strongly Disagree Disagree Neutral Agree Strongly Agree

14.) I believe my current method of notetaking is working well.

Strongly Disagree Disagree Neutral Agree Strongly Agree

15.) Please explain why you answered the way you did in the previous question.

APPENDIX C

LEARNING STYLE INVENTORY QUESTIONNAIRE

Adapted from *Learning to Study Through Critical Thinking, J.A. Beatrice)*

Please note that participation in this survey is completely voluntary and participation or non-participation will not affect your grade or class standing in any way.

Directions: Circle the letter before the statement that best describes you.

1. If I have to learn how to do something, I learn best when I:

(V) Watch someone show me how.

(A) Hear someone tell me how.

(K) Try to do it myself.

2. When I read, I often find that I:

(V) Visualize what I am reading in my mind's eye.

(A) Read out loud or hear the words inside my head.

(K) Fidget and try to "feel" the content.

3. When asked to give directions, I:

(V) See the actual places in my mind as I say them or prefer to draw them.

(A) Have no difficulty in giving them verbally.

(K) Have to point or move my body as I give them.

4. If I am unsure how to

(V) Write it in order to determine if it looks right.

(A) Spell it out loud in order to determine if it sounds right.

(K) Write it in order to determine if it feels right.

5. When I write I:

(V) Am concerned with how neat and well spaced my letters and words appear.

(A) Often say the letters and words to myself.

(K) Push hard on my part or pencil and can feel the flow of the words.

6. If I had to remember a list of items, I would remember it best if:

(V) Wrote them down.

(A) Said them over and over to myself.

(K) Move around and used my fingers to name each item.

7. I prefer teachers who:

(V) Use a board or overhead projector while they lecture.

(A) Talk with lots of expression.

(K) Use hands-on activities.

8. When trying to concentrate, I have a difficult time when:

(V) There is a lot of clutter or movement in the room.

(A) There is a lot of noise in the room.

(K) I have to sit still for any length of time.

9. When solving a problem I:

(V) Write or draw diagrams to see it.

(A) Talk myself through it.

(K) Use my entire body or move objects to help me think.

10. When given written instructions on how to build something, I:

(V) Read them silently and try to visualize how the parts will fit together.

(A) Read them out loud and talk to myself as I put the part together.

(K) Try to put the parts together first and read later.

11. To keep occupied while waiting, I:

(V) Look around, stare, or read.

(A) Talk or listen to others.

(K) Walk around, manipulate things with my hands, or move/shake my feet as I sit.

12. If I had to verbally describe something to another person, I would:

(V) Be brief because I do not like to talk at length.

(A) Go into great detail because I like to talk.

(K) Gesture and move around while talking.

13. If someone were verbally describing something to another person, I would:

(V) Try to visualize what he/she was saying.

(A) Enjoy listening bur want to interrupt and talk myself.

(K) Become bored if her/his description got too long and detailed

14. When trying to recall names, I remember:

(V) Faces but forget names

(A) Names but forget faces

(K). The situation where I met the person rather than the person's name or face

APPENDIX D

SEVENTH GRADE ECOSYSTEMS PRE/POST ASSESSMENT

Ecosystems Unit Test: Multiple Choice

Directions: Read each question and all responses before answering. Select the letter of the correct answer.

1.) Which statement is true of all biotic factors?
   a. They are/were once alive
   b. They are renewable
   c. They use photosynthesis
   d. They use chemosynthesis
2.) Which type of organism would you find at the lowest level of an energy pyramid?
   a. Producers
   b. Herbivores
   c. Consumers
   d. Decomposers
3.) Sam ate a bacon, lettuce, and tomato sandwich. Which term best describes Sam?
   a. Producer
   b. Herbivore
   c. Omnivore
   d. Decomposer
4.) All of the living and nonliving things in a given area
   a. Consumers
   b. Ecosystem
   c. Climate
   d. Producers
5.) Organisms that eat other organisms
   a. Consumers
   b. Ecosystem
   c. Climate
   d. Producers
6.) A snake that eats mice
   a. Herbivore
   b. Omnivore
   c. Carnivore
   d. Detritivore
7.) Using carbon dioxide, water, and light energy to make food
   a. Photosynthesis
   b. Cellular Respiration
   c. Carbon Cycle
   d. Chemosynthesis
8.) A person who eats meat, vegetables, and fruits
   a. Producer
   b. Omnivore
   c. Herbivore
   d. Carnivore
9.) Bacteria in the soil turn this element into a form usable by plants in this cycle of matter
   a. Carbon Cycle

b. Nitrogen Cycle
c. Water Cycle
d. Oxygen Cycle

10.) A mouse that eats corn and grass
a. Producer
b. Herbivore
c. Carnivore
d. Omnivore

11.) Non-living things in an ecosystem
a. Biotic
b. Abiotic
c. Energy
d. Matter

12.) Click on ALL of the abiotic factors
a. Climate
b. Trees
c. Water
d. Atmosphere
e. Soil
f. Detritivore

13.) Matter moves through an ecosystem in what type of pattern?
a. Zig Zag
b. Flow
c. Cycle
d. Food Web

14.) Energy moves through an ecosystem in what type of pattern?
a. Zig zag
b. Flow
c. Cycle
d. Food web

15.) The amount of energy passed from one trophic level to the next
a. 90%
b. 100%
c. 75%
d. 10%

16.) Energy in an ecosystem originates from
a. Planets
b. Food
c. Sun
d. Electricity

17.) A model that shows how energy flows in an ecosystem through feeding relationships
a. Energy Pyramid
b. Food Pyramid
c. Food Chain
d. Food Web

18.) A model of energy transfer that shows how food chains in a community are interconnected.
   a. Energy Pyramid
   b. Food Pyramid
   c. Food Chain
   d. Food Web

19.) A model used to show the amount of energy available in each step of a food chain
   a. Energy Pyramid
   b. Food Pyramid
   c. Food Chain
   d. Food Web

20.) Which is NOT a characteristic of life?
   a. Reproduction
   b. Energy
   c. Breathing
   d. Growth and Development
   e. Homeostasis

21.) The ability to maintain steady internal conditions when outside conditions change
   a. Climate
   b. Organization
   c. Homeostasis
   d. Reproduction

22.) Producers that have no access to sunlight must use this method to obtain energy
   a. Consume
   b. Photosynthesis
   c. Chemosynthesis
   d. Eat

23.) What is NOT part of the water cycle?
   a. Participation
   b. Precipitation
   c. Evaporation
   d. Condensation

24.) The steps of an energy pyramid are known as
   a. Autotrophs
   b. Heterotrophs
   c. Food Levels
   d. Trophic Levels

25.) Which grouping could be considered a population in the Kalahari Desert?
   a. All the meerkats in the desert
   b. All the plants and animals in the desert
   c. All the living and nonliving parts of the desert

26.) All of the populations of different species that live in the same area at the same time
   a. Biosphere
   b. Biotic Potential
   c. Population

d. Community

27.) Anywhere on, within, or around the Earth where life exists
a. Biosphere
b. Biotic Potential
c. Population
d. Community

28.) The growth of a population if there were no limiting factors.
a. Biosphere
b. Biotic Potential
c. Population
d. Community

29.) The struggle in a community for the same resources, such as food or water
a. Carrying Capacity
b. Competition
c. Limiting Factor
d. Population Density

30.) The size of a population compared to the amount of space available
a. Carrying Capacity
b. Competition
c. Limiting Factor
d. Population Density

31.) Anything that restricts the size of a population
a. Carrying Capacity
b. Competition
c. Limiting Factor
d. Population Density

32.) The largest number of individuals of one species that an environment can support
a. Carrying Capacity
b. Competition
c. Limiting Factor
d. Population Density

33.) What is migration?
a. Population Growth
b. Population Extinction
c. Population Movement

34.) A species at risk but not yet endangered
a. Extinct
b. Threatened
c. Endangered

35.) Number of offspring produced over a period of time
a. Birthrate
b. Death Rate
c. Exponential Growth

36.) Number of individuals that die over a period of time
a. Birth Rate
b. Death Rate

c. Exponential Growth

37.) A species that has died out
   a. Threatened
   b. Endangered
   c. Extinct

38.) This occurs when a population has abundant resources and ideal conditions (usually occurs with microbes such as bacteria).
   a. Carrying Capacity
   b. Exponential Growth
   c. Birthrate

39.) What would be a good habitat for a cactus?
   a. Sunlight
   b. Desert
   c. Warm
   d. Dry

40.) Which of the following would be a good niche for a bird?
   a. Flying, hunting, nesting
   b. Worms, Water, Leaves
   c. Tree, House, Hole
   d. Warm, Dry, Underground

41.) Why are predators important to prey?
   a. Predators are not important to prey
   b. Predators keep the prey population balanced
   c. Predators need prey to get energy

42.) Identify the type of interaction in the following scenario: A coyote usually hunts for rodents such as rabbits, gophers, and squirrels.
   a. Predator-prey
   b. Commensalism
   c. Mutualism
   d. Parasitism

43.) Identify the type of interaction in the following scenario: Hermit crabs live in shells made by snails that have abandoned them.
   a. Predator-prey
   b. Commensalism
   c. Mutualism
   d. Parasitism

44.) Identify the type of interaction in the following scenario: A wasp will lay its eggs on the back of a caterpillar called the catalpa worm. When the larvae hatch, they will feed on the caterpillar and kill it
   a. Predator-prey
   b. Commensalism
   c. Mutualism
   d. Parasitism

45.) Identify the type of interaction in the following scenario: The Egyptian plover lands inside a Nile crocodile's mouth, getting a good meal and cleaning the crocodile's teeth at the same time.

a. Predator-prey
b. Commensalism
c. Mutualism
d. Parasitism

46.) A geographic area on earth that contains ecosystems with similar biotic and abiotic factors
a. Habitat
b. Community
c. Ecosystem
d. Biome

47.) Areas classified as the same biome have similar
a. Size and space
b. Climate and organisms
c. Size and organisms
d. Space and temperature

48.) The process of one ecological community gradually changing into another is known as ecological
a. Succession
b. Recession
c. Evolution
d. Revolution

49.) A stable community that no longer goes through major ecological changes
a. Primary Succession
b. Secondary Succession
c. Climax Community
d. Final Succession

50.) Ecological succession occurring in new areas of land with little to no soil is known as
a. Primary Succession
b. Secondary Succession
c. Climax Community
d. Final Succession

51.) Ecological succession occurring in areas where existing ecosystems have been disturbed or destroyed, but soil is still present.
a. Primary Succession
b. Secondary Succession
c. Climax Community
d. Final Succession

52.) The first species to live on new or undisturbed land
a. Original Species
b. Pioneer Species
c. Climate Species
d. Final Species

APPENDIX E

EIGHTH GRADE EARTH'S STRUCTURE PRE/POST ASSESSMENT

Earth's Structure Unit Test: Multiple Choice

Directions: Read each question and all responses before answering. Select the letter of the correct answer.

1.) The distance in degrees north or south of the equator
    a. Latitude
    b. Longitude
    c. Prime Meridian
    d. Poles
2.) This type of map shows the detailed shapes of Earth's surface (elevation).
    a. Political Map
    b. Road Map
    c. Tectonic Map
    d. Topographic Map
3.) The height above sea level
    a. Elevation
    b. Latitude
    c. Longitude
    d. Relief
4.) Lines on a topographic map connecting points of equal elevation
    a. Contour Intervals
    b. Index Contours
    c. Elevation Lines
    d. Contour Lines
5.) The elevation difference between contour lines that are next to each other
    a. Index Contour
    b. Contour Interval
    c. Contour Distance
    d. Distance Interval
6.) A reference contour line that is usually shaded in darker than the others and is labeled with the elevation
    a. Index Contour
    b. Index Map
    c. Contour Line
    d. Contour Elevation
7.) The force that every object exerts on all other objects because of their masses (responsible for the formation of the Earth)
    a. Momentum
    b. Gravity
    c. Equilibrium
    d. Static
8.) Earth's entire solid body
    a. Hydrosphere
    b. Geosphere
    c. Thermosphere
    d. Atmosphere
9.) Earth's layers are primarily due to differences in

a. Gravity
b. Weight
c. Volume
d. Density

10.) The layers of the earth formed because the Earth was, at one point, extremely hot and
a. Molten/Melted
b. Solid
c. Gaseous

11.) The amount of mass in a material per unit of volume is known as an object's
a. Mass
b. Volume
c. Matter
d. Density

12.) Earth's interior is
a. Solid
b. Liquid
c. A combination of solid and liquid
d. Neither solid nor liquid

13.) The outermost layer of the Earth that is brittle and rocky is known as the
a. Core
b. Crust
c. Mantle
d. Ocean

14.) The crust is subdivided into which two types
a. Atmospheric and Geospheric
b. Lithospheric and Asthenospheric
c. Oceanic and Continental
d. Inner and Outer

15.) What happens to the temperature and pressure as the depth in the Earth increase?
a. They decrease
b. They do not change
c. One decreases while the other increases
d. They both increase

16.) Tectonic plates are located within which sublayer of the Earth?
a. Lithosphere
b. Asthenosphere
c. Mantle
d. Core

17.) The upper part of the mantle just below the lithosphere is composed of a plastic-like layer that the tectonic plates move on top of, known as the
a. Lithosphere
b. Asthenosphere
c. Mantle
d. Core

18.) The thick middle layer in the solid part of the Earth is known as the

a. Inner Core
b. Outer Core
c. Crust
d. Mantle

19.) The outer core is
a. Solid
b. Liquid
c. Gas
d. All answers are correct

20.) The inner core is
a. Solid
b. Liquid
c. Gas
d. All answers are correct

21.) Rocks are often made of different _____, which are naturally occurring inorganic solids with a definite chemical composition and an orderly arrangement of atoms/ions.
a. Crystals
b. Minerals
c. Fragments
d. Textures

22.) Molten rock stored beneath Earth's surface is known as
a. Lava
b. Magma
c. Liquid
d. Solid

23.) Molten rock stored on or above Earth' surface is known as
a. Lava
b. Magma
c. Liquid
d. Solid

24.) The resistance of a mineral to being scratched is known as
a. Hardness
b. Streak
c. Luster
d. Color

25.) The color of a mineral in powdered form is known as
a. Hardness
b. Streak
c. Luster
d. Color

26.) If a mineral breaks with smooth, flat surfaces, it is said to have
a. Fracture
b. Hardness
c. Density
d. Cleavage

27.) If a mineral breaks and forms uneven surfaces it is said to have
   a. Fracture
   b. Hardness
   c. Density
   d. Cleavage

28.) The way a mineral reflects or absorbs light is known as
   a. Hardness
   b. Streak
   c. Luster
   d. Color

29.) A natural solid mixture of minerals or grains
   a. Rock
   b. Mineral
   c. Crystal
   d. Gemstone

30.) There are how many major rock types?
   a. 1
   b. 2
   c. 3
   d. 4

31.) Rocks formed from cooling magma/lava
   a. Metamorphic
   b. Clastic
   c. Sedimentary
   d. Igneous

32.) The series of processes that change one type of rock into another type
   a. Water Cycle
   b. Carbon Cycle
   c. Igneous Cycle
   d. Rock Cycle

33.) When volcanic material erupts, cools, and crystallizes on Earth's surface, it forms _____ igneous rock.
   a. Intrusive
   b. Extrusive
   c. Felsic
   d. Mafic

34.) Rocks that form from the compaction and cementation of fragments of other rocks
   a. Igneous
   b. Metamorphic
   c. Sedimentary
   d. Crystallized

35.) Any process that affects the structure or composition of a rock in a solid state as a result of changes in temperature, pressure, or the addition of chemical fluids
   a. Compaction
   b. Cementation
   c. Extrusivism

d. Metamorphism

36.) The mechanical and physical processes that change objects on Earth's surface over time
   a. Erosion
   b. Weathering
   c. Deposition
   d. Compaction

37.) A mixture of weathered rock, rock fragments, decayed organic matter, water, and air
   a. Dirt
   b. Magma
   c. Soil
   d. Pores

38.) The breaking down of rock by physical processes
   a. Chemical Weathering
   b. Erosion
   c. Deposition
   d. Mechanical Weathering

39.) Type of weathering which changes the materials that are part of the rock into new materials.
   a. Chemical Weathering
   b. Erosion
   c. Deposition
   d. Mechanical Weathering

40.) An example of chemical weathering
   a. Oxidation
   b. Abrasion
   c. Ice Wedging
   d. Animals Burrowing

41.) An example of mechanical weathering
   a. Carbonic Acid
   b. Acid Precipitation
   c. Abrasion
   d. Dissolving

42.) Layers of soil formed from the movement of the products of weathering
   a. Layers
   b. Properties
   c. Horizons
   d. Formation Factors

43.) The removal of weathered material from one location to another
   a. Erosion
   b. Weathering
   c. Deposition
   d. Compaction

44.) The laying down or settling of eroded material is known as
   a. Erosion

b. Weathering
c. Deposition
d. Compaction

45.) A large mass of ice that formed on land and moves slowly across Earth's surface is known as
a. An ice sheet
b. An ice cap
c. A glacier
d. An ice slab

46.) The downhill movement of a large mass of rocks or soil because of the pull of gravity
a. Mass Wasting
b. Flood
c. Earthquake
d. Glacial Groove

47.) Which of the following is a landform created by erosion?
a. Sand Dunes
b. Deltas
c. Caves/Caverns
d. Alluvial Fans

48.) Which of the following is a landform created by deposition?
a. Delta
b. V-Shaped Valley
c. Sea Arches
d. Meander

49.) Which of the following is a negative impact of human activity on weathering/erosion/deposition on Earth's surface?
a. Planting trees
b. Irresponsible farming/grazing
c. Avoiding building on the flood plain
d. Conserving Forests

50.) Which of the following is a positive impact of human activity on weathering/erosion/deposition on Earth's surface?
a. Increased greenhouse gases (global warming)
b. Destructive mining practices
c. Irresponsible farming/grazing practices
d. Planting more trees

APPENDIX F

SCIENCE NOTEBOOK RUBRIC/SELF ASSESSMENT

You will grade your notebook at the end of each unit by the criteria listed below. The total number of points (out of 50) will be doubled when combined with my grade to give you a final score out of 100.

	To get all 10 points has:	**To get 8 points has:**	**To get 6 points has:**	**To get 4 points has:**
Right/Left Pages (Input & Output): *Are all pages completed?*	All pages are present and completed to date.	1 page is missing or incomplete.	2 pages are missing or incomplete.	3 or more pages are missing or incomplete.
Bellwork: *Are all assignments glued in and completed? (Absent = excused)*	Has all bellwork completed to date.	Missing (or incomplete) 1-2 bellwork assignments.	Missing (or incomplete) 3-4 bellwork assignments.	Missing (or incomplete) 5 + bellwork assignments.
Order/Organization: *Are all pages numbered and in the correct order?*	All pages are in order and properly numbered.	1-2 pages are out of order/ not properly numbered.	3-4 pages are out of order/ not properly numbered.	5 + pages are out of order/ not properly numbered.
Effort: *Is color used appropriately/ Is their strong evidence of effort put forward?*	All pages demonstrate effort, creativity, and/or detail.	Most pages demonstrate effort, creativity, and/or detail.	Some pages demonstrate effort, creativity, and/or detail.	Few pages demonstrate effort, creativity, and/or detail.
Content: *Are the Table of Contents and Glossary up-to-date?*	Table of Contents and Glossary are up-to-date.	Missing 1-2 entries in TOC or Glossary.	Missing 3-4 entries in TOC or Glossary.	Missing 5 + entries in TOC Glossary.

APPENDIX G

SEVENTH GRADE LIFE STRUCTURE/FUNCTION PRE/POST ASSESSMENT

7th Grade Life Science Unit 2 Pre/Post Test
Structure and Function of Life

Directions: For the following questions, please circle the letter of the correct answer.

1.) Which of the following is NOT one of the characteristics of life?
- **a.) Growth/Development**
- **b.) Breathing/Respiration**
- **c.) Use of Energy**
- **d.) Homeostasis**

2.) The smallest unit of life is known as the
- **a.) Atom**
- **b.) Compound**
- **c.) Element**
- **d.) Cell**

3.) To be considered living, an organism has to have
- **a.) 5 characteristics of life**
- **b.) 4 characteristics of life**
- **c.) 6 characteristics of life**
- **d.) 3 characteristics of life**

4.) The largest group living things are classified into today is the
- **a.) Species**
- **b.) Kingdom**
- **c.) Domain**
- **d.) Genus**

5.) Living things are named using binomial nomenclature, a system that gives organisms names using their
- **a.) Genus/Species**
- **b.) Domain/Kingdom**
- **c.) Class/Order**
- **d.) Family/Genus**

6.) Why do scientists use scientific names for living things?
- **a.) To be specific**
- **b.) To make communication more effective**
- **c.) To reduce confusion**
- **d.) All of the above are true**

7.) A series of descriptions arranged in pairs that leads to the identification of an unknown organism is known as a
- **a.) Legend**
- **b.) Cladogram**
- **c.) Dichotomous Key**

8.) What is the difference between a light microscope and an electron microscope?
- **a.) Electron microscopes don't use light**
- **b.) Electron microscopes can magnify an image better**
- **c.) Electron microscopes can make an image much clearer**
- **d.) All of the above are true.**

9.) In the mid 1600s, scientist Robert used a microscope to make a very important discovery, which was the discovery of

a.) Hair
b.) Bones
c.) Cells
d.) Blood

10.) When you get extremely warm, your body sweats, helping you to cool down. This is an example of which characteristic of life?
a.) Homeostasis
b.) Reproduction
c.) Growth/Development
d.) Energy Use

11.) Over 70% of a cell's volume is made up of
a.) Cytoplasm
b.) Water
c.) Macromolecules

12.) Robert Hooke discovered these when he looked through a microscope at cork (cork oak tree's bark) and saw tiny little openings.
a.) Atoms
b.) Molecules
c.) Cells

13.) Almost two decades after the cell was discovered, Rudolf Virchow proposed that all cells come from pre-existing cells. This became part of the
a.) Cell Theory
b.) Atomic Theory
c.) Theory of Evolution

14.) Organelles are made of smaller substances, known as _____, which include proteins, lipids, carbohydrates, and nucleic acids.
a.) Atoms
b.) Compounds
c.) Macromolecules

15.) When offspring inherit all of their DNA from one parent, they are
a.) Genetically identical
b.) Genetically diverse
c.) Chromosomes
d.) Zygoes

16.) A form of asexual reproduction in which offspring grow from a part of a parent plant is known as
a.) Animal regeneration
b.) Vegetarian
c.) Vegetative reproduction
d.) Tissue culture

17.) A form of asexual reproduction in which offspring grow from a piece of its parent animal is called
a.) Animal regeneration
b.) Vegetation
c.) Vegetative reproduction
d.) Tissue culture

18.) A body cell with pairs of chromosomes
- **a.) Haploid**
- **b.) Diploid**
- **c.) Plant**

19.) Reproductive cell that has only one chromosome from each pair
- **a.) Haploid**
- **b.) Diploid**
- **c.) Plant**

20.) Process by which one diploid cell divides into four haploid cells
- **a.) Regeneration**
- **b.) Mitosis**
- **c.) Photosynthesis**
- **d.) Meiosis**

21.) Two chromosomes that have genes for the same traits in the same order
- **a.) Centromeres**
- **b.) Homologous chromosomes**
- **c.) Homozygous chromosomes**
- **d.) Daughter cells**

22.) Producing genetically identical organisms in a laboratory
- **a.) Mitosis**
- **b.) Fission**
- **c.) Budding**
- **d.) Cloning**

23.) Production of an offspring through the combination of egg and sperm
- **a.) Meiosis**
- **b.) Animal regeneration**
- **c.) Sexual reproduction**
- **d.) Asexual reproduction**

24.) The new cell formed by fertilization
- **a.) Sperm**
- **b.) Zygote**
- **c.) Egg**
- **d.) Starfish**

25.) Reproduction in unicellular eukaryotes
- **a.) Mitotic Cell Division**
- **b.) Fission**
- **c.) Budding**
- **d.) Cloning**

26.) Offspring growing on the body of its parent
- **a.) Fission**
- **b.) Budding**
- **c.) Cloning**
- **d.) Regeneration**

27.) The joining of an egg (female reproductive cell) and a sperm (male reproductive cell)
- **a.) Fission**
- **b.) Budding**

c.) Cloning
d.) Fertilization

28.) Which process is a step in sexual reproduction?
a.) Budding
b.) Fertilization
c.) Regeneration
d.) Mitosis

29.) Which situation is NOT an example of asexual reproduction?
a.) A pair of rabbits mating
b.) A bacterium splitting in half
c.) A paramecium undergoing mitosis
d.) A new sea star grown from half a sea star

30.) Cell division in prokaryotes that forms two genetically identical cells
a.) Mitotic cell division
b.) Fission
c.) Budding
d.) Cloning

31.) Which phase occurs first?
a.) Prophase II
b.) Telophase I
c.) Metaphase II
d.) Prophase I

32.) The process by which the cytoplasm splits and two new cells form is known as
a.) Mitosis
b.) Cell Growth
c.) Cell Division
d.) Cytokinesis

33.) The cell cycle is divided into how many parts?
a.) 1
b.) 2
c.) 3
d.) 4

34.) Mitosis (one part of the cell cycle) is divided into how many phases?
a.) 1
b.) 2
c.) 3
d.) 4

35.) Spindle fibers form in which phase of mitosis
a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

36.) Chromosomes uncoil back into chromatin in which phase of mitosis?
a.) Prophase
b.) Metaphase
c.) Anaphase

d.) Telophase

37.) Cytokinesis begins at the end of which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

38.) Chromosomes become visible during which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

39.) Sister chromatids separate into individual chromosomes during which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

40.) The cell stretches out as opposite ends are pushed apart in which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

41.) Centrioles (organelles that form spindle fibers) separate during which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

42.) Each chromosome is connected to a spindle fiber during which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

43.) The nucleolus disappears and the nuclear envelope (membrane) breaks down during which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

44.) Two nuclear envelopes (membranes) form during which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

45.) The chromosomes line up across the middle of the cell during which phase of mitosis?

a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

46.) The individual chromosomes move apart during which phase of mitosis?
a.) Prophase
b.) Metaphase
c.) Anaphase
d.) Telophase

47.) A process used by cells to obtain energy when oxygen levels are low.
a.) Photosynthesis
b.) Cellular Respiration
c.) Fermentation

48.) The carbon dioxide waste product of cellular respiration is used by plants in what process?
a.) Osmosis
b.) Mitosis
c.) Photosynthesis

49.) Cellular respiration occurs in which two organelles?
a.) Nucleus and vesicles
b.) Cytoplasm and mitochondria
c.) Golgi Apparatus and Endoplasmic Reticulum

50.) Cells process energy from food into this energy storage compound
a.) DNA
b.) HMS
c.) AIG
d.) ATP

51.) The movement of substances from high concentration to low concentration using transport proteins.
a.) Active Transport
b.) Facilitated Diffusion
c.) Endocytosis
d.) Passive Transport

52.) The movement of substances into and out of the cell using the cells energy
a.) Active transport
b.) Facilitated Diffusion
c.) Endocytosis
d.) Passive transport

53.) The movement of water through a membrane
a.) Osmosis
b.) Endocytosis
c.) Hydrolysis
d.) Facilitated diffusion

54.) Food coloring spreading through water and perfume spreading through the air are both examples of

a.) Diffusion
b.) Osmosis
c.) Active Transport
d.) Facilitated Diffusion

55.) If the cell were a school, the mitochondria would be
a.) The bathroom
b.) The office
c.) The bricks
d.) The walls
e.) The cafeteria
f.) The doors
g.) The boiler room

56.) 55.) If the cell were a school, the cell membrane would be
a.) The bathroom
b.) The office
c.) The bricks
d.) The walls
e.) The cafeteria
f.) The doors
g.) The boiler room

57.) If the cell were a school, the cell wall would be
a.) The bathroom
b.) The office
c.) The bricks
d.) The walls
e.) The cafeteria
f.) The doors
g.) The boiler room

58.) If the cell were a school, the chloroplasts would be
a.) The bathroom
b.) The office
c.) The bricks
d.) The walls
e.) The cafeteria
f.) The doors
g.) The boiler room

59.) If the cell were a school, the nucleus would be
a.) The bathroom
b.) The office
c.) The bricks
d.) The walls
e.) The cafeteria
f.) The doors
g.) The boiler room

60.) Cells that contain membrane bound organelles, such as the endoplasmic reticulum and golgi apparatus are known as

a.) Prokaryotic
b.) Eukaryotic
c.) Multicellular

61.) Cells that have no nucleus and no membrane bound organelles
a.) Prokaryotic
b.) Eukaryotic
c.) Unicellular

62.) Which structures are not found in animal cells?
a.) Cell Wall
b.) Cell membrane
c.) Mitochondria
d.) Chloroplasts
e.) Central Vacuole
f.) Nucleus
g.) Ribosomes

63.) Structures inside cells with specialized functions
a.) Atoms
b.) Macromolecules
c.) Organelles

64.) Macromolecules that contain genetic material and information for making proteins
a.) Proteins
b.) Lipids
c.) Carbohydrates
d.) Nucleic Acids

65.) All cells are surrounded by this structure, which serves to protect the cell from the outside environment and lets things pass in and out
a.) Cell Wall
b.) Cell Membrane
c.) Nucleus
d.) Mitochondria

EIGHTH GRADE GEOLOGIC CHANGE PRE/POST ASSESSMENT

8th Grade Earth Science Unit 2 Pre/Post Test

Geologic Changes

Directions: For the following questions, please circle the letter of the correct answer.

1.) When two oceanic plate boundaries meet, what crustal feature forms?
   a.) Plate Tectonics
   b.) Seafloor Spreading
   c.) Folded Mountains
   d.) Volcanic Island Arc
2.) Which scientist is given credit for coming up with the idea of continental drift?
   a.) Alfred Darwin
   b.) Henry Hess
   c.) Alfred Wegener
   d.) Isaac Newton
3.) The plates of the earth float on a semi-fluid layer known as the
   a.) Lithosphere
   b.) Crust
   c.) Mantle
   d.) Asthenosphere
4.) Tectonic plates are broken up pieces of the Earth's
   a.) Asthenosphere
   b.) Crust
   c.) Lithosphere
   d.) Mantle
5.) What was the name of the supercontinent tha tAlfred Wegener proposed existed approximately 225 million years ago?
   a.) Gondwanaland
   b.) Eurasia
   c.) Pangaea
   d.) Laurasia
6.) Which landform is most likely to form at a continent-to-ocean convergent boundary?
   a.) Rift Valley/Continental Rift
   b.) Mid-Ocean Ridge
   c.) Transform Fault
   d.) Deep Ocean Trench
7.) Which of the following ideas/theories came first in the evolution of plate tectonics?
   a.) Theory of Plate Tectonics
   b.) Continental Drift Hypothesis
   c.) Seafloor Spreading
8.) The process by which a denser plate sinks below a more buoyant plate is known as
   a.) Convection

b.) Conduction
c.) Subduction
d.) Buoyancy

9.) Which two mountain ranges (one in Europe and one in the USA) appear to be of the same age, composition, and structure?
a.) Himalayas and Alps
b.) Caledonians and Rockies
c.) Rockies and Himalayas
d.) Appalachians and Caledonians

10.) At this type of plate boundary, large mountain ranges are created because both of the plates are of equal density, and neither one subducts beneath the other.
a.) Continent-Ocean Convergent
b.) Continent-Continent Convergent
c.) Divergent
d.) Transform

11.) This type of plate boundary occurs where two plates separate, and often forms rift valleys and mid-ocean ridges.
a.) Continent-Continent Convergent
b.) Divergent
c.) Continent-Ocean Convergent
d.) Transform

12.) What causes the motion of the material within the asthenosphere?
a.) Differences in temperature
b.) Differences in density
c.) Convection currents
d.) All of the above

13.) Convection currents in the mantle produce a force called _____, circulating and dragging the lithosphere similar to the way a conveyor belt moves items at a supermarket checkout.
a.) Ridge Push
b.) Slab Pull
c.) Basal Drag

14.) Which of the following is NOT a force that causes plate motion?
a.) Ridge Push
b.) Slab Pull
c.) Friction

15.) What evidence has been found on the seafloor supporting seafloor spreadin/continental drift?
a.) Sediments are similar in age all over the seafloor
b.) Sediments are older closer to midocean ridges
c.) Sediments are younger further from the ridge
d.) Corresponding magnetic stripes on both sides of the midocean ridge

16.) Why were people hesitant to believe the continental drift hypothesis? (circle all that apply)
- a.) There was no explanation for how the continents were moving
- b.) There was no evidence to support the hypothesis
- c.) There was no way to se eor measure the continents moving
- d.) Satellites showed that the continents weren't moving
- e.) Continents moved so slowly
- f.) Nobody knew what forces could cause the continents to move

17.) Seafloor spreading is supported by which of the following pieces of evidence (circle all that apply)
- a.) Continental drift
- b.) Thermal energy at midocean ridges
- c.) Plate tectonics
- d.) Age of sediments on the seafloor
- e.) Magnetic stripes on the seafloor
- f.) Plate boundaries

18.) What are the four main effects of volcanic eruptions (circle all that apply)
- a.) Hydrothermal Explosions
- b.) Lava Flows
- c.) Seismic Activity
- d.) Ground Deformation
- e.) Mudflows
- f.) Ash Falls
- g.) Water Acidity
- h.) Pyroclastic Flows

19.) What do scientists monitor to help them predict if/when a volcano will erupt? (circle all that apply)
- a.) Hydrothermal Explosions
- b.) Lava Flows
- c.) Seismic Activity
- d.) Ground Deformation
- e.) Mudflows
- f.) Ash Falls
- g.) Water Acidity
- h.) Pyroclastic Flows

20.) Magma that is high in silica is said to have
- a.) High viscosity
- b.) Low viscosity

21.) Which of the following factors helps to determine how explosive a volcanic eruption will be (circle all that apply).
- a.) Volcano Size
- b.) Amount of dissolved gases in the magma
- c.) Magma viscosity

d.) Air temperature
e.) Air pressure
f.) Magma composition/chemistry

22.) Which type of volcano is very large, has gentle slopes, and is made from basaltic lavas?
a.) Composite
b.) Cinder Cone
c.) Supervolcano
d.) Shield

23.) Small, steep-sided volcanoes made from moderately explosive eruptions are known as
a.) Shield volcanoes
b.) Composite Volcanoes
c.) Cinder Cone Volcanoes
d.) Supervolanoces/Calderas

24.) Where are two main places that volcanoes occur?
a.) Faults
b.) Plate Boundaries
c.) Mountains
d.) Hot Spots

25.) What type of plate boundaries are volcanoes more likely to occur at?
a.) Convergent
b.) Divergent
c.) Transform
d.) Convergent and Divergent

26.) What method is often used to find the location of an earthquake's epicenter?
a.) Richter Scale
b.) Triangulation
c.) Seismometer
d.) Mercalli Scale

27.) Which of the following is NOT a type of seismic wave?
a.) Primary
b.) Secondary
c.) Tertiary
d.) Surface

28.) Scientists who study earthquakes are known as
a.) Seismologists
b.) Seismograms
c.) Seismometers
d.) Seismic Waves

29.) An instrument used to measure and record ground motion and used to determine the distance seismic waves travel.
a.) Seismometer

b.) Seismogram
c.) Seismologist

30.) A graphical illustration of seismic waves
a.) Seismometer
b.) Seismogram
c.) Seismograph

31.) Which type of seismic wave travels only on Earth's surface closest to the epicenter of an earthquake?
a.) S-wave
b.) Primary Wave
c.) Surface Wave
d.) Tertiary Wave

32.) Which seismic wave cannot travel through liquids.
a.) S-wave
b.) P-wave
c.) Surface waves
d.) Tertiary waves

33.) Which seismic waves travels parallel to the rock motion?
a.) P-wave
b.) S-Wave
c.) Surface wave

34.) What are the three types of faults?
a.) Convergent, Divergent, Transform
b.) Shear, Tension, Compression
c.) Strike-slip, Normal, Reverse
d.) All answers are correct

35.) A break in earth's lithosphere where one block of rock moves toward, away from, or past another is known as a
a.) Plate boundary
b.) Fault
c.) Hot Spot
d.) Subduction Zone

36.) The location within the earth where seismic waves originate due to rock motion along a fault is known as the
a.) Epicenter
b.) Primary
c.) Secondary
d.) Focus

37.) The location on Earth's surface directly above the exact location of the earthquake is known as the
a.) Epicenter
b.) Primary
c.) Secondary

d.) Focus

38.) What conditions aid in the formation of fossils?
a.) Hard parts and slow burial
b.) Hard parts and rapid burial
c.) Soft parts and rapid burial
d.) Soft parts and slow burial

39.) What is the numerical age in years of a rock or object known as?
a.) Absolute Age
b.) Relative Age
c.) Radioactive Age
d.) Isotopic Age

40.) Which principle of geology states that the same processes that occur today are similar to those that have occurred in the past?
a.) Catastrophism
b.) Uniformitarianism
c.) Superposition
d.) Inclusions

41.) What makes a good index fossil?
a.) Lived a long time and was abundant
b.) Lived a long time and was scarce
c.) Lived a short time and was scarce
d.) Lived a short time and was abundant

42.) Which item is NOT a fossil?
a.) Ancient bacterial colonies preserved in ice
b.) A dead tree on a forest floor
c.) A mosquito in amber
d.) A Velociraptor footprint

43.) What is relative age?
a.) An exact age of a rock/fossil
b.) A radiometric age of a rock/fossil
c.) The age of a rock/fossil with respect to others around it
d.) A cousin who is 16 years old

44.) What is a half-life?
a.) The numerical age of half of the daughter material
b.) The numerical age, in years, of a rock or object
c.) The time required for half the amount of radioactive material to decay
d.) What happens after you drink unicorn blood

45.) Which object could accurately be dated using carbon-14?
a.) Earth itself
b.) A sedimentary rock
c.) A mammoth preserved in ice
d.) A metal sword from the bronze age

46.) If a rock contain pieces of another rock, the pieces are older than the rock they are in due to the principle of
   a.) Relative Age
   b.) Superposition
   c.) Lateral Continuity
   d.) Original Horizontality
   e.) Absolute Age
   f.) Inclusions
   g.) Crosscutting Relationships

47.) Sediments are originally deposited in flat layers due to the principle of
   a.) Superposition
   b.) Lateral Continuity
   c.) Original Horizontality
   d.) Inclusions
   e.) Crosscutting Relationships

48.) Sediments/layers extend outwards in all directions unless they thin out or hit a barrier; this is known as the principle of
   a.) Superposition
   b.) Lateral Continuity
   c.) Original Horizontality
   d.) Inclusions
   e.) Crosscutting Relationships

49.) In undisturbed rock layers, older layers are below younger layers. We know this because of the principle of
   a.) Superposition
   b.) Lateral Continuity
   c.) Original Horizontality
   d.) Inclusions
   e.) Crosscutting Relationships

50.) If one feature cuts across another, the feature tha tit cuts across is older. This is due to
   a.) Superposition
   b.) Lateral Continuity
   c.) Original Horizontality
   d.) Inclusions
   e.) Crosscutting Relationships

51.) Which isotope would be most useful for dating some of Earth's oldest rocks?
   a.) One with a long half-life
   b.) One with a short half-life
   c.) One with two different half-lives
   d.) A young one

52.) A surface where rock has eroded away, producing a break or gap in the rock record

a.) Correlation
b.) Unconformity
c.) Index Fossil
d.) Inclusion

53.) A rock sample contains 25% Uranium and 75% lead. Which element is the parent isotope?
a.) Uranium
b.) Lead
c.) Carbon

54.) A rock contains 50 grams of parent isotope to start with. How many grams of parent isotope will remain in the rock after five half-lives?
a.) 25
b.) 50
c.) 12.5
d.) 1.5625

55.) A rock sample contains 25% Uranium and 75% Lead. If the half-life of Uranium is only ten years, how old is the rock?
a.) 10 years old
b.) 20 years old
c.) 5 years old
d.) 30 years old