

THE EFFECTS OF NOTE TAKING STRATEGIES ON RETENTION OF SCIENCE
CONTENT ON HIGH SCHOOL STUDENTS

by

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A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2019

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ABSTRACT

Throughout my own educational career, both high school and college, note-taking has always been an important part. As a teacher in the classroom of today, I still try to instill that practice in my students. I know the powers that be would like the standard lecture and note taking go by the wayside. I believe it can still be part of the educational process and the art of note taking can be beneficial to students in their future educational or career endeavors. Over the past fifteen years as a teacher, I have seen students struggle with note taking. The standard practice for lecture and note taking is to display a PowerPoint presentation and while the teacher talks and clicks through the presentation, the student scramble to write things down. Is there a strategy that would be beneficial to the students and help with retention of the lecture material? This is what lead me to my classroom research project. The main research question for the project asks if certain note taking strategies influence retention of science concepts in high school students. The project consisted of three note taking strategies: student-generated, partial (fill in the blanks), and guided. The data collection consisted of pre- and post-assessments, a summative assessment, and a teacher journal. Based on the data obtained, there was about a four percent increase in retention when guided notes were used by student compared to the student-generated notes. A larger discrepancy exists between the partial note strategy and the other two strategies. I believe the data shows no particular note taking strategy outweighs another.

INTRODUCTION AND BACKGROUND

Project Background

Note taking has always been a part of life and learning, both inside and outside of the classroom. In some form or another, it will be required of students beyond high school whether they pursue a path of higher education or into the job market. As I have seen over the years of teaching high school, juniors and seniors lack note taking skills. So, as they move on to higher education they struggle with the rigors of lectures in college. I have had former students, even my daughters make the claim that high school did not prepare them for this. Note taking is not only a benefit for college but also in the workplace. I cannot tell you how many meetings I have been involved with both in education and industry where I had to take notes. What do you think a boss is going to think when you ask him to repeat what he just said? I am always taking notes or jotting things down, maybe it is just age or it is something I have always done.

When former students come back to visit while they are on break from college, beside the small talk about college, I always ask, how are your classes going. In our discussions about this, there seems to be a common theme. We, meaning high school staff, are not preparing for the rigors of college. They talk about things like homework, studying, and taking notes. Students nowadays, at least at my high school, do very little homework and studying outside of school. Taking notes comes in different forms at our school. Some teachers do not even give notes or they will give the students a handout of the notes and expect the students to write things down as the notes are discussed. Other teachers will have a PowerPoint or Google Slides presentation and some students will

copy everything on the slide and some students will not copy anything. The point is there is no rhyme or reason for taking notes. I am just as guilty doing some of this myself. Note taking is a part of learning, both inside and outside the classroom. When high school students continue to college to pursue higher education, it becomes a big part of their life in college.

Unfortunately, lectures are a part of the learning process in the classroom. In an ideal world, the teacher would provide some type of inquiry approach to the lesson and have the students build their own model of thinking towards the concept. I think most teachers would agree on this point, but with limited time and resources, there are times when a lecture is a necessity and students are required to take notes on the lecture. Most of the time there is no formal teaching of note taking strategies and students are forced to do it a particular way. There are students that try to write everything down, students that write the main points, and students that do not write anything. How the notes are presented can be a determination on what the students do. Is there some type of presentation, like a PowerPoint or is the teacher just talking about the concept? Besides how students take notes, the other issue is what is done with the notes after the lecture. Do the students review them that night or several days later or only the night before the test?

Research Questions

The purpose of this study is to see if a particular note taking strategy had an impact on the learning of high school students. I also looked at how these strategies effect the retention of the material covered in a lecture. This study was chosen because I

believe note taking is an important skill, especially for college students. During my literature review, several authors claimed that 85-90% of college professors use the lecture as their main tool to teach students the content.

Primary Research Question:

What is the effect of different note taking strategies on high school students' retention of science concepts?

Secondary Research Questions:

- a) Is one note taking strategy better than another based on retention?
- b) What is the impact of the study on me as a teacher?

CONCEPTUAL FRAMEWORK

Research Studies

Note taking has been around the field of education for a long time. It is not only an important part of education, but it is also beneficial to life outside of education. There is historical perspective to note taking. References to note taking research date back to the 1930s. In 1971, Robert Palmatier did a study on note taking techniques. Up to this time, five studies had been performed on note taking techniques since the turn of the century. The four note-taking methods included in the study were: "a) the traditional Formal Outline Procedure (FOP), b) a three-column method described by Walter Pauk (1962) of Cornell University (PCU), c) a two-column method developed over several student generations at the University of Michigan and Syracuse University, known as the Bartush Active Method (BAM); and d) a No-Special-Method Control (NMC)" (Palmatier, 1971). A side note, the PCU method would become known as the Cornell Method. These

methods or procedures were chosen for the study based on their ease of learning, efficacy of recording, and utility for studying lecture material. Prior to the training, the students were tested over material that would be used in the study. Training consisted of instruction in the format of how the notes were to be organized. Training sessions included practice in taking notes with each method and those notes being evaluated for quality. Notes were taken from taped lectures.

The instrument used was known as the “Taped Note-Taking Test.” It was made up of three forms, “each form consisted of a 10-minute tape recorded lecture followed by 30 comprehensive questions over the lecture material” (Palmatier, 1971 p. 237). The notes were evaluated on quality. The students did this for each of the methods of note taking. The notes were compared to an outline of the lecture for quality. The number of words used was also a factor. The scoring of the notes resulted in three ratios: completeness, clarity, and conciseness. The statistical analysis used for the three forms was an Analysis of Variance for Repeated Measures. On the efficacy of the notes a One-way Analysis of Variance was used. The FOP method had the highest level for essential content. This fits in line with the how to study experts as the preferred method of the times. The BAM method showed actual improvement over the pre-training level, whereas the other two methods showed little or no improvement. It was suggested the training time was not adequate to see the note-taking skill increase. The BAM method improvement could be due to ease of learning the method.

Since Palmatier’s study, the research into note taking began to take a more analytical process. Researchers are considering concepts like cognition, working

memory, encoding and external storage function. In the search for articles pertaining to the topic, two themes began to develop: the rationale of note taking with regard to learning and cognition and the benefits of guided notes. Several articles outline the basis of the rationale and demands of note taking regarding learning and cognition. According to Makany, Kemp, and Dror (2009), note taking depends on the “working memory. When taking notes, we maintain a short-term buffer in order to acquire, mentally represent, select and understand the continuous flow of incoming new information and to update and interact with the already-stored knowledge” (Makany, Kemp, & Dror, 2009, p. 620). Piolat, Olive, and Kellogg (2005) also explain the “what and why of note taking in terms of working memory: When listening, more operations are concurrently engaged and, thus, taking notes from a lecture places more demands on working memory resources.” (p. 292). Taking notes means there is understanding of what is presented in a lecture and is written down (Piolat, Olive, & Kellogg, 2005). When taking notes, we need a short-term memory buffer (interpreted as working memory) in order to process the incoming information, and to update the already stored information (Piolat et al., 2005). The amount of information we can actively maintain in our focus of attention, or primary memory is limited to about four items, and that additional items must be retrieved from what they term as secondary memory (Bui & Myerson, 2014). It is important to give students enough time to write within the lecture since their working memory can only hold so much at a time. This seems straight forward, but according to Piolat et al., not all forms of note taking are created equal.

Several researchers distinguish two functions of note taking: encoding and

external storage. “The encoding function suggests the process of recording notes facilitates learning” (Kiewra, DuBois, Christian, McShane, & Meyerhoffer, 1991 p. 240). To determine the encoding function, a comparison is done between students who write notes down during the lecture and students who just listen to the lecture. Neither is allowed to review before the test. “The external storage function suggests the review of the notes stored in a written form facilitates performance” (Kiewra et al., 1991 p. 240). This function is determined by allowing one group to review their notes and the other group not allowed to review their notes. It is thought that both functions aid in learning, but the external storage function is the more important of the two. Di Vesta and Gray (1972) claimed note taking not only helps with recording a lecture but also helps with restudy later (Di Vesta & Gray, 1972). “Note taking also helps at the time of the lecture by promoting the encoding of information in ways that facilitate later retrieval”(Bui & Myerson, 2014, p. 12). A new study by Kiewra et al., “reclassified the traditional external storage function as an ‘encoding plus storage’ function and propose a new, independent external storage function represented by those who review notes but who have not previously viewed (or encoded) the lecture”(Kiewra et al., 1991, p. 240). They accomplished this by not allowing the students to view the lecture, but instead provided them with notes from a fellow student. Now three note taking functions are provided for studies: take notes and no review (encoding), take notes and review (external storage plus) and borrow notes and review (independent external storage).

How much is learned will depend on the cognitive function and the note taking strategy. Makany et al., 2009 conducted a study to show some note taking strategies may

be better than others. They used adult learners to compare the cognitive performance with traditional note taking versus nontraditional note taking. Another name for traditional notes is linear notes and for nontraditional notes is non-linear. Some researcher use the term “matrix” (Kiewra et al., 1991 p. 241). Linear is basically writing out notes in sentence form, where non-linear/matrix would be like concept mapping. “The results showed that linear note takers did not learn as much as the non-linear note takers. Using cognitively compatible (non-linear) note taking techniques is important for deeper understanding” (Makany, Kemp, & Dror, 2009, p. 633). It is important to use a technique that works with the brain’s ability to manage information. “Non-linear note taking is cognitively less demanding and allows the note taker to focus on learning the material instead of how to organize notes” (Makany et al., 2009, p. 621). When the cognitive load is lessened during a lecture the academic performance of the note taker should increase. (Titsworth, 2004) “Building in cues for lecture notes and using non-linear/non-traditional note taking formats creates a visual structure that allows for a reduction in cognitive load and can ultimately make the note taking process more effective” (Titsworth & Kiewra, 2004 p. 448). Integration of lecture cues into teacher provided notes is a way to increases usage of non-linear notes.

Notes provided by the teacher have shown to be valuable to student learning. Many studies have been done on this type of note taking strategy and have shown an impact on student learning. One such study was conducted on college students by Cornelius and Owen-Deschryver (2008). Students were given two types of instructor generated notes: partial and full. This happened over the course of the semester. The

partial notes were in outline form where the students filled in the missing information as they listened to the lecture. The full notes were handouts of a complete set of notes and the students looked through the notes as the instructor lectured. Scores from four exams were analyzed to look for evidence on impact to learning. The results showed that partial notes had a higher impact on scores over the full note scores. The authors discussed reasons why partial notes were more beneficial than full notes. “Providing incomplete notes encourages students to elaborate on and encode material during lectures...and through the process of taking notes, students gain some mastery of the material” (Cornelius & Owen-DeSchryver, 2008, p. 7).

In the article by Cornelius and Owen-Deschryver, in the conclusion the authors discussed guided notes which lead to further research on the topic. Guided notes can be placed into the category of partial notes. A review was conducted to summarize the results of eight studies done on guided notes (Konrad, Joseph, & Eveleigh, 2009). They defined guided notes as instructor provided and non-linear (Konrad et al., 2009). The review showed the effectiveness of guided notes and provided recommendations for everyday use in the classroom. Both secondary and postsecondary students were targeted in the studies. According to an article by Konrad et al. (2009),

Results of some studies showed student preferred guided notes over traditional notes. The reduction in frustration levels with note taking seem to be the reason. Guided notes are an effective way to help teachers promote active participation during lectures and provide students with thorough and accurate reference for exam preparation (p. 441).

Higher level thinking is another benefit of guided notes. Stopping points can be built in to lectures to “pause and think critically, ask questions, connect with personal experience, relate prior knowledge, and generate new ideas” (Konrad et al., 2011 p.132).

A recommendation of the review was for teachers to start the lecture off with a prompting question to trigger student's prior knowledge. Activating prior knowledge prepares the mind for new information and strengthens connections, which is essentially constructivism. Organizing the new information into what is already there is fundamentally how learning is done" (Konrad et al., 2011 p. 132).

Neef, McCord, and Ferreri (2006) conducted a study that show relevance to methodology and data collection. In the study, 46 students were subjected to an eight-week examination of the effects of guided notes verses completed notes. (Neef, Mccord, & Ferreri, 2006). The basic delivery of the notes for the presentation was PowerPoint. A standard format was used. The first slide stated objectives, second slide had an opening question, the next slide started the new material, and so on. Completed notes were identical to the slides in the presentation and for guided notes, key elements were left off the slide. A quiz on the previous day's material was given at the beginning of class the following day. Scores were not counted in the data analysis for students that missed the lecture. (Neef et al., 2006). This basic design continued throughout the study, alternating between guided notes and completes notes each week. The quiz scores reflected the strategy used in the previous lecture. The authors did not describe how the data was collected but they reported students preferred the provided notes over taking their own notes. They also preferred guided notes over complete notes (Neef et al., 2006). The study done by Cornelius & Owen-DeSchryver, 2008 was closely related to Neef et al., (2006) except it was partial notes instead of guide notes. Student's scores on test were higher with the partial notes. Cornelius & Owen-DeSchryver (2008) made the claim:

“Partial notes...may provide a nice balance in terms of providing students with some notes, which they report as helpful, and still require encoding and higher-level processing of information, which will ultimately improve learning and performance” (p. 11).

Going into the literature review, I thought I had a clear path for my action research project. I wanted to consider different note taking methods (Cornell, Outline, Sentence, and Split Page) and how they affect a student’s long-term memory. Due to the lack of research articles on these methods, I have ventured down a different road. Most notetaking research deals with the cognitive aspect of note taking, things like working memory, encoding, and external storage. When it comes to actual strategies of note taking, most research deals with student generated and teacher generated (partial, complete, and guided). So, I considered strategies like student generated, partial and guided as my treatments for the action research.

METHODOLOGY

As I formulated my research questions, I decided to structure the research in a way that shows how some note taking strategies could affect the retention of information in my students. The primary focus was going to be the impact of different note taking strategies on high school science students’ retention of science concepts dealing with Earth’s oceans. The secondary focus was based on what were the attitudes of students towards the note taking strategies and what was the impact of this study on my teaching.

Treatment

The treatment for the study included three note taking strategies: student-generated notes (SGN), partial notes (PN), and guided notes (GN). When conducting the literature review, these note taking strategies were used in one way or another in past

research studies. So, keeping in line with those studies, I implemented the strategies into my research study. The first phase of the treatment was student-generated notes. This strategy is the easiest to implement, and it gave a baseline for the second and third phases of the treatment. Basically, the students took notes how they normally do. No special instructions were given to the students on how or what to take. Over the past years of teaching high school this is how I have students take notes. During the lecture, students took notes in their science notebooks. I implemented notebooks in my classes this year, so as not to throw off the expectation, the note taking was done in their notebooks. Notebooks were collected after each strategy so I could look through them. It was up to the student to deem what was important from the lecture and write it down, with little or no encouragement from me.

The second phase of the treatment, partial notes were introduced. Students received a handout that supplements the lecture. The handout was in line with the style of the presentation with some information missing. Diagrams and some difficult points were included on the handout. The students were required to follow along with the lecture and fill out what is missing or what they feel was important. By providing some of the lecture material, students were given the opportunity to listen and be actively engaged during the lecture, instead of trying to get everything presented down on paper. According to the research, "During lecture learning, students continuously and simultaneously listen, select important ideas, hold and manipulate lecture ideas, interpret the information, decide what to transcribe, and record notes"(Kiewra et al., 1991 p. 241). Allowing the student to be actively engaged with the lecture should increase the retention

of the material. The handout was then stapled into their notebook.

In the final phase of the treatment, the use of guided notes was introduced. This strategy was modeled after descriptions found in the article, *Using Guided Notes to Enhance Instruction for All Students* (Konrad, Joseph, & Itoi, 2011). The article provides specific suggestions for creating and using guided notes to promote higher order thinking skills in students. Guided notes are an extension of the student generated or partial notes strategy. I chose this model because the author, Konrad, seems to be the leading authority on guided notes and note taking. The article provides suggestions for the structure of the guided notes. I used these suggestions to tailor the notes to my specific classroom and teaching style. The main suggestion is to provide cues (symbols) on the handout that tell the students to interact (do something) during the lecture. For example, a picture of an ear, would tell a student to put down their pencil and listen (Konrad, Joseph, & Itoi, 2011). The cues are imbedded in the presentation and correspond to the same cue on the slide or handout provided to the student. This strategy was new to the students. Instruction for this strategy had to be provided prior to its use and a handout of all cues and their meanings given to the students. In this phase, I should have seen the most engagement with the students and lecture. Retention of the material should have been at its highest. Guided notes are more interactive than the other two strategies. The cues given throughout the presentation guided the students to the important aspects of the lesson. Students knew when to ask questions, highlight key concepts, and when diagrams were important.

The implementation of the treatment consisted of one cycle of three phases. A

cycle consisted of student-generated notes, partial notes, and guided notes. The plan was to implement the treatment cycle within one unit. Most of my units have a least three lectures within the unit. Each lecture in the unit used one of the note taking strategies. The duration of the unit is two to three weeks depending on the content for that unit. Table 1 below was the timeline for the cycle of the treatments and data collection.

Timeline

The timeline for the treatment and data collection occurred in the months of March and April of the spring semester of 2019. The content covered during the data collection is our Earth’s Ocean unit. This unit is broken into three areas; Oceans/Ocean Characteristics, Seawater Composition, and Ocean Circulation, Currents, and Tides.

Table 1 below illustrate the timeline in more detail.

Table 1
Treatment Timeline

Activity	Treatment	Topic	Dates
Cycle of Treatment – Earth’s Oceans			3/18/19 – 4/30/19
Administer the pre-assessment for the unit.			
Lecture	Student-generated notes (SGN)	Oceans/Ocean Characteristics	3/18 - 3/21
Administer post-treatment assessment			
Tally student scores on pre-and post-assessments			
Tally data from the pre-treatment survey			
Lecture	Partial Notes (PN)	Seawater Composition	3/25 –3/29
Administer post-treatment assessment and tally scores			
Continue with entries in Teacher Journal			
Lecture	Guided Notes (GN)	Oceans: Circulation/Currents/Tides	4/4– 4/18
Administer post-treatment assessment and tally scores			
Continue with entries in Teacher Journal			
Administer summative assessment over unit			

Instrumentation

Prior to each phase (note taking strategy), students were given a pre-assessment. The pre-assessments consisted of five questions to test for prior knowledge of the topic. The pre-assessments are set up as misconception probes. Lecture content can be adjusted depending on the outcome of the misconceptions. Student-generated notes were used in the first phase of the treatment cycle. Students took notes any way they wanted to and following the lecture the notes were collected. The notes were looked over and returned the following day. Depending on the concept, there would be an activity or two to reinforce the content. A post-assessment was given after the lecture and activities to check for understanding and retention of lecture material. With the next phase of the treatment, partial notes, commenced. The students received a handout with some of the lecture content and diagrams included. We proceeded through the lecture and students took what information they deem relevant for the lecture. Following the lecture, the handouts were collected, checked, and returned. Class activities preceded the lecture and then a post-assessment on the lecture material was given. The same procedure was implemented for the final phase of the treatment. In this phase the guided notes were the note taking medium. Prior to this phase, it was necessary to spend some class time to talk about the guided note process and the expectations for the notes. Students were given a handout of the cues (symbols) used in the guided notes. After the three phases of the cycle were complete, a summative test was given on the unit. The test was multiple choice and broken into three sections, each section consisted of material for each of the three phases. This was to provide data relevant to each of the note taking strategies.

There was no review guide provided to the students prior to the test. The student used the notes from the treatments to study for the test. The summative test concluded the cycle of the treatment.

The research matrix in Table 2 summarizes the type of instruments that were used to collect the data. It shows a triangulation between the instruments and the research questions. Instruments were designed to ensure they measured the target it was intended to measure, creating a greater validity of the data. The triangulation of the data should have removed any bias and helped to ensure reliability of the data. Several of the treatments in this study were peer reviewed during the EDCI 509 class in the Fall of 2018. They were also reviewed by my advisor Walt Woolbaugh. Approval for this action research project, first, had to be approved through the Cypress-Fairbanks Independent School District's Department of School Improvement and Accountability (Appendix A). Once approval was granted, I had to get approval through Montana State University's Institutional Review Board, where an exemption was granted (Appendix B).

Table 2
Matrix of Data Collection Instruments

	Pre-assessment	Post-assessment	Summative test	Teacher Journal	Sample of Student Notes
Research Questions					
What is the impact of different note taking strategies on high school students?	X	X	X	X	X
Is one strategy better than another based on retention?	X	X	X		X
What is the impact of the study on me as a teacher?				X	X

Demographics

I teach Earth and Space Science (ESS) at Jersey Village High School in Houston, Texas, which is part of the Cypress-Fairbanks Independent School District. This year I taught four classes of ESS. One class is On-level and the other three classes are K-level (upper-level) with gifted and talented (GT) students mixed in. K-level students are of higher ability, but not quite GT. On-level students are students of normal ability. The On-level classes are where our special education and 504 students are placed. In the K-level/GT classes, the pace of the class is quicker and the content is explored in more depth. ESS is normally a senior elective science class. Juniors are allowed in the class if they are concurrently enrolled in a physics class or have had physics already.

For this research project, my On-level class did not participate in the study. My three K-level classes participated in the study. My second period had seventeen, third

period had twenty-one, and fourth period had sixteen. One student was not allowed to participate due to parent concerns because of the student's 504 plan. The sample size was around fifty-three students.

DATA AND ANALYSIS

The data for the study consisted of both quantitative and qualitative data. Quantitative data was collected using pre-and post-assessments and the summative tests. A teacher journal and samples of student notes were used to collect the qualitative data for the study.

Quantitative

As mentioned earlier in the paper, a pre-assessment was given prior to the unit. It consisted of five questions. It was used to identify prior knowledge and possible misconceptions of the content. The data from the pre-assessment allowed me to target specific areas in the content lectures. The pre-assessment was administered at the beginning of the cycle. At the end of each phase (note taking strategy), a post-assessment was administered. It consisted of fifteen questions that targeted the lecture material and checked for understanding of the content. The data should have shown how the note taking strategy worked. Within a week of the end of the cycle a summative test was administered to the students. The students could study their notes for the test and no review for the test was given. The test consisted of forty-five multiple-choice questions, which was 15 questions for each lecture. It was important to keep the difficulty level of the questions equal throughout the test. Each group of fifteen questions represented each of the note taking strategies in the cycle. The results provided a quantitative look at how

the note taking strategies were impacting the students' retention and if any difference exist between the different groups.

The pre-assessments were created based on the idea of misconception probes, which I picked up in my EDCI 504 class. I have used probes frequently in my classes since then. For this project, two of the probes were newly created and one was created during my EDCI 504 class, which has been used each year since I took the class. The Oceans/Ocean Characteristic pre-assessment consisted of five statements dealing with common misconceptions about oceans and their characteristic (Appendix C). Each statement was answered with either agree or disagree and the students explained why they chose that answer. For this pre-assessment, the correct answer for each statement was disagree.

According to the data, two statements stand out showing misconceptions held by the students. Statement #1, "The oceans are deepest in the middle." and statement #3, "The ocean is blue from the sky's reflection" (Figure 1).

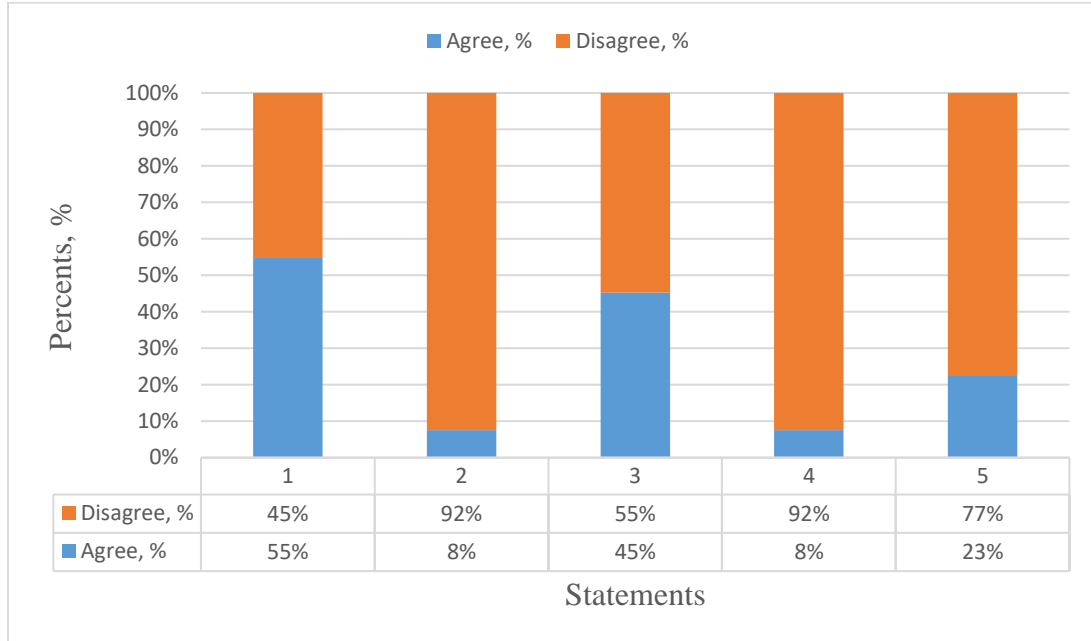


Figure 1. Student responses to pre-assessment – oceans/ocean characteristics, ($N=53$).

Both these statements are about a 1:1 ratio in the responses. The correct response to statement #1 is disagree which was chosen by forty-five percent of the students. The correct reasoning behind this is the deepest part of our oceans are where trenches are formed. Ocean trenches are formed at convergent boundaries or subduction zones. These areas are closer to continental plates than the middle of the oceans. Even though just under half answered disagree, several had the wrong reasoning. Three students answered a question with a question, “Where is the middle?” One student answered, “Oceans are not perfect.” Another stated, “The Earth’s seafloor is uneven, meaning the deepest parts aren’t in one uniform area.” Four students were closer to the correct reasoning. The best answer out of the group was, “Depends on if they’re near plate boundaries, some aren’t in the middle. The other three made the claim, “it’s the deepest in the trenches.” When I look at the reasoning behind choosing to agree, which was fifty-five percent, a big misconception showed up. The most popular reason, eight students,

was “they are shallow at the edges.” The next popular reason, five students, was “It’s far from land.” Three students claim it just gets deeper in the middle. The most unusual reason was “because the beach explains it.”

In statement three, “the ocean is blue from the sky’s reflection”, fifty-five answered disagree. I would have thought the percent would have been higher. One of the prerequisites for my class is Physics, which is taken junior year. One of the concepts taught is light and color. The correct reasoning for this statement is, the blue wavelength of visible light is absorbed at a greater depth. Until it is absorbed, it is reflected to the surface, thus giving our oceans their blue color. The other wavelengths are absorbed at the surface. Of the fifty-five percent that chose disagree, only five students had the correct reasoning. They knew it was blue due the reflection of the blue wavelength and the other colors were absorbed. The rest of the students that chose disagree had their reasoning all wrong. Two student’s responses were not even scientific. One student claimed, “That’s what my third-grade teacher told us” and another said, “because Mr. Higgins said so.” Some of the other response, “yes, because oxygen makes them blue,” “the salt and algae in the water,” and “the sky is blue from the ocean.”

The previous pre-assessment lead into the first note taking strategy, student-generated notes. With this strategy, the students are going to take notes how they normally take them. This is how we have done it most of the school year. I went through a PowerPoint presentation on basic information about our ocean and characteristics of the oceans. This presentation took one class period. I did purposefully leave information off slides and just talked about it. The hope was students would write down information that

was not on the slide. Notebooks were collected so I could look through them. A couple of days after the lecture a post-assessment was given (Appendix D). The student used only their notes to study for the assessment. If we look at the data in Figure 1 for statement 3, “The ocean is blue from sky reflection,” we see fifty-five percent chose to disagree and forty-five percent chose agree. We see an improvement in those numbers by the time the post-assessment is taken. Seventy percent chose the correct answer to question number four on the post-assessment. The question was, “Our oceans appear bluish-green to blue due to the _____.” The correct answer was the absorption of white light. We can also see a slight improvement on the summative assessment. Seventy-four percent got the question correct.

In the second pre-assessment, the misconception probe is dealing with seawater composition (Appendix E). This is an actual probe I created for EDCI 504 and have used in my classes since then. In the scenario, a group of students are discussing the saltiness of the water. Each student has a different conception of how the oceans got their saltiness. Thirty-nine percent of the students chose Heather, who had the correct statement and fifty-three chose Trinh. (Figure 2).

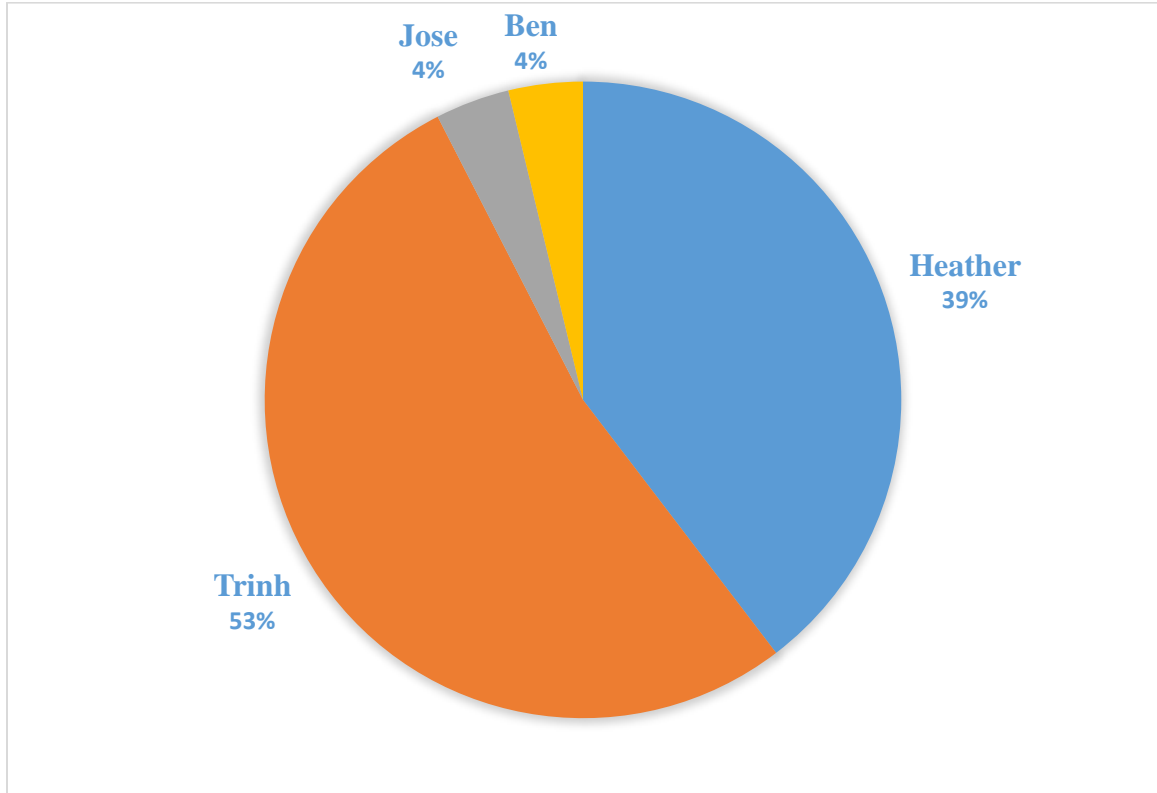


Figure 2. Student responses to pre-assessment - seawater composition, ($N=53$).

Heather's conception, "She thinks it come from the dissolving of rocks and soil due to acid rain and runoff" and Trinh conception, "She thinks it is from the sediment and rock on the ocean floor," were the main choices for most students. The salt in the ocean come from the weathering and erosion of rocks on the land. Rain that falls on the land is slightly acidic due to the formation of carbonic acid, which forms from water and carbon dioxide. As the acid rain breaks down rock it creates ions that are carried to the oceans. Though this process makes of most up the salt content of our oceans, the outgassing of element for Earth's interior add to the salinity. Overtime, the concentrations of these ions increase and create the salinity of our oceans.

Even though fifty-three percent chose Trinh, eight of the student's reasoning did not match Trinh's conception. Their reasoning supported Heather's conception. One

student claimed, “I believe Trinh has the most correct answer because of the erosion of the rock and sediment overtime, which leads to the saltiness.” Another student thought, “I think the salt come from minerals of eroded and broken-down rocks.” All eight students had the general idea for their reasoning. Most of the students that chose Trinh had basically the same reasoning, “Salt has a composition of minerals from rocks and sediments. The rocks and sediment on the ocean floor create the salt in our oceans.” There were some outrageous explanations though. One student claimed, “The sedimentary rocks look like they contain salt because they are shaped like salt and there are clear speckles that look like salt.” Another student thinks, “I believe the saltiness has always been on planet Earth, the water came from comets and the saltiness from the rocks which the comet landed on.” I had two students use race to justify their explanations, because Trinh is Asian. “Trinh sounds Asian and they are usually smarter” and “she’s Asian and Asians are smart.” Of the thirty-nine percent that chose Heather, their reasoning was sound. Everyone claimed it somehow had to do with erosion or runoff and the dissolving of rock on the Earth’s surface. One student said, “It is from the breakup of the rocks and within them is the salt.” Another student claimed, “it’s because the rain and runoff wear on the rocks, which break it down and release it into the oceans.”

The seawater pre-assessment lead into the second note taking strategy of the treatment, partial notes (Appendix F). In this strategy, the students follow along with the lecture and fill in the blanks and the diagrams as they appear in the presentation. At the end of the period, the notes were collected and checked for accuracy and handed back the following day. The post-assessment was given a few days later (Appendix G). Looking

at the post-assessment for the seawater composition segment, fifty-nine percent of the students chose the correct answer when asked how the salt content was created in our oceans. So, we see about a twenty percent increase between the pre- and post-assessment. Now, if we compare the summative assessment to the post-assessment there is a considerable increase. One hundred percent of the students chose the correct answer. I believe the increase is due to students making a more concrete effort to study for the summative assessment as compared to the post-assessment. In our grading scale, the summative is weighted at fifty percent (major grade) whereas the post-assessment is only twenty percent (daily grade). The major grade will have a larger effect on grade because there are few of them. The students have the tendency to worry about major grades more than the daily grades.

In the final segment of the treatment, we dealt with the concepts of ocean circulation, currents, and tides. Just as before, the pre-assessment was given first (Appendix H). This one was similar in structure like the first pre-assessment. It had five common misconceptions where the students chose either agree or disagree. The data shows two misconceptions stand out among my students. These are statement number two, “The ocean currents are caused by the tides” and statement number five, “Winds and sunlight control the climate much more than the ocean currents or sea-surface temperatures.” See Figure 3 below.

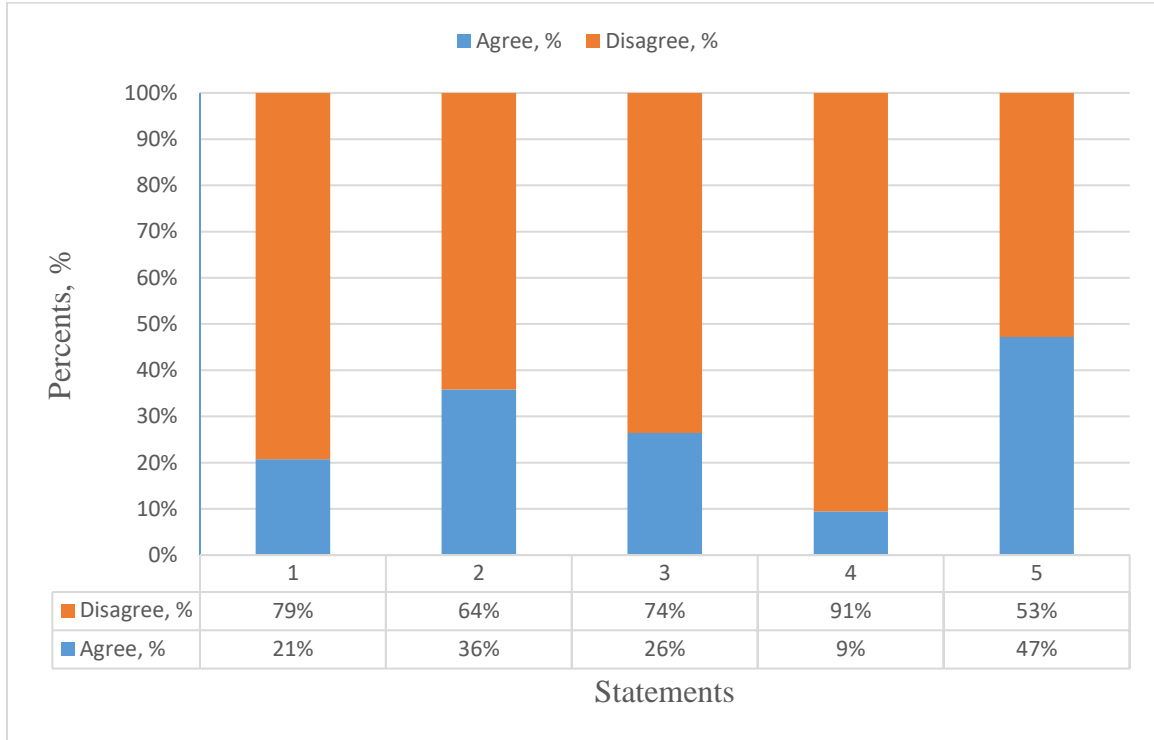


Figure 3. Student responses to pre-assessment – ocean circulation, currents, and tides, ($N=53$).

The correct response for the two statements is disagree. Ocean currents are masses of water that flow from one place to another. These currents develop from the friction between the ocean and the wind that blows across the surface. The prevailing wind patterns, rotation of the Earth and location of landmasses dictate the direction the currents flow. Looking at statement number two, we see sixty-four percent chose to disagree compare to thirty-six that chose to agree. Even though sixty-four percent chose to disagree, only six had the right reasoning for choosing that answer. I had several students say, “currents are caused by the wind.” One student went a little further and claimed, “they are caused by the direction of the wind and its speed.” The rest of the students that chose disagree had a variety of wrong reasoning. Five of the students claimed the moon had a part in ocean currents. “the ocean currents are created by the

moon's gravitational pull," "they are caused by the moon's gravity," and "the moon plays a part." Some of the other reasoning dealt with the weather, undersea conditions, the magnetic field, and the jet stream. The students that chose agree as the answer had a variety of reasoning also. There were six students that said, "I don't know." One student claimed, "they are determined by waves." The rest of the agree still thought tides and currents were related. They said, "currents move the water to create tides," "tides are what bring in the current," and "because of cause and effect."

When we look at statement number five, "Winds and sunlight control the climate much more than the ocean currents or sea-surface temperature," we see a more 1:1 ratio between the answers. Fifty-three percent chose to disagree and forty-seven percent chose to agree. The climate of Earth is a complex mechanism. There are many factors that work together to create our climate. The ocean currents and sea-surface temperatures are the driving forces for the climate. Currents moving from low latitudes into the higher latitudes bring warmer water which transfers heat into the cooler regions. The opposite occurs where the currents flow out of the high latitudes into the lower latitudes. This can lead to a ten-degree difference in temperature on opposite sides of a continent like North and South America. On this statement, I had several students write in neutral claiming they couldn't choose to agree or disagree. They also wished they had a neutral answer on all the pre-assessments. The consensus with this group was they claimed the sunlight and wind is what determines the sea-surface temperatures but were unsure how it affected the climate. The forty-seven percent that chose to agree with the statement said both the sun and wind were big factors in our climate. "Sunlight is a big factor in climate" and "the

winds and sunlight change the temperature completely.” One student said, “water has less of an affect.” Yes, these are helping factors toward the driving forces of the climate.

Of the fifty-seven percent that chose to disagree, about half of the students had a reasoning other than the right one. An example from one student was, “water vapor keeps the climate consistent.” Another student said, “Its’s usually moisture and the jet stream. Also, one claimed, “sea-surface temperatures control the winds.” The other half, about fourteen students, had either the right reasoning or something that was close to it. While several agreed it is the ocean currents and sea-surface temperatures affecting the climate, more believe the sea-surface temperatures have the greatest effect. Two students said, “Climate is determined by ocean temperatures” and “surface temperatures are more impactful than winds/currents alone.” One student claimed, “ocean currents and water around the world affect it the most. (things like the water cycle, world temperatures, hurricanes, and all weather).”

The third and final pre-assessment lead into the final note taking strategy, guided notes. For this strategy, I came up with six symbols or icons that I incorporated into a Power Point to tell the student to do something as we proceeded through the presentation (Appendix I). They would either write the information down or just listen, highlight the key ideas or concepts, draw the diagram, or have an opportunity to ask questions. The presentation was broken up into the three parts, circulation, currents, and tides. We spent about fifteen minutes prior to the first lecture talking about how the guided notes would work and the student had a handout of the symbols to use during the lectures. After all, three lectures were complete, notebooks were collected, checked, and given back to the

students. The post-assessment was administered a few days later (Appendix J).

Statement two on the pre-assessment dealt with tides being caused by ocean currents and thirty-six percent agreed with the statement. On the post-assessment, three questions were similar with statement two. They were questions one, three, and twelve. The data shows the student answered correctly; question one – forty percent, question three – thirty-eight percent, and question twelve – ninety-four percent. So, there was slight increases in two of the questions, one and three, and a significant increase in question twelve. The post assessment had three questions, numbers two, four, and eleven, that were like statement five of the pre-assessment. The data for these questions shows students answered correctly; question two – fifty-three percent, question four - seventy-two percent, and question eleven – one hundred percent. As for the summative assessment, four questions related to statements of the pre-assessment, two for statement two and two for statement five. Of the fifty-three students, eighty-one percent answered question six and one hundred percent answered question twenty-four correctly compared to the thirty-six percent that answered statement two of the pre-assessment incorrectly. If we compare pre-assessment statement five to the summative questions twelve and thirty-one, sixty percent and ninety-eight percent answered correctly, respectively. Based on the data above, we saw improvement from the two statements from the pre-assessment. In some cases, it is only slight and some it is significant improvement. I would go as far to say; the guided notes help increase the retention of the students. As stated above, the difference between the post and summative assessments could solely be based on grade weight for each.

The main purpose of the research project was to see how effective the three note taking strategies were on student's retention of science concepts. Student-generated notes were used as a baseline for the other two strategies. Table 3 below shows the comparison in the data of the three post-assessments and the summative assessment. The mean percent was calculated for each assessment and a Paired t-Test was run to determine the p-value. For the t-Test, pre-assessments two and three were each paired with pre-assessment one. It was also done with the summative assessment.

Table 3
Means and p-Values for % Correct on Post-Assessments and Summative Assessment

	Mean, %	Difference	p-Value
Post-Assessment #1 (SGN) Ocean Characteristic	62.4	NA	NA
Post-Assessment #2 (PN) Seawater Composition	54.3	8.0	0.004
Post-Assessment #3 (GN) Circulation, Currents, & Tides	66.8	4.4	0.056
Summative Assessment (AS) All Concepts	77.4	23.1	0.000

Note. (N=53). AS = all strategies used.

Based on the p-values there is no significant difference between the student-generated notes compared to the partial notes or guided notes. A box and whisker plot graph was created to show the students' percent correct for each of the assessments (Figure 4). The percent correct for each student was plotted for each of the post-assessments and the summative assessment. The blue plot (SGN) is post-assessment one (baseline), the orange plot (PN) is post-assessment two, the grey plot (GN) is post-assessment three, and the gold plot (AS) is the summative assessment.

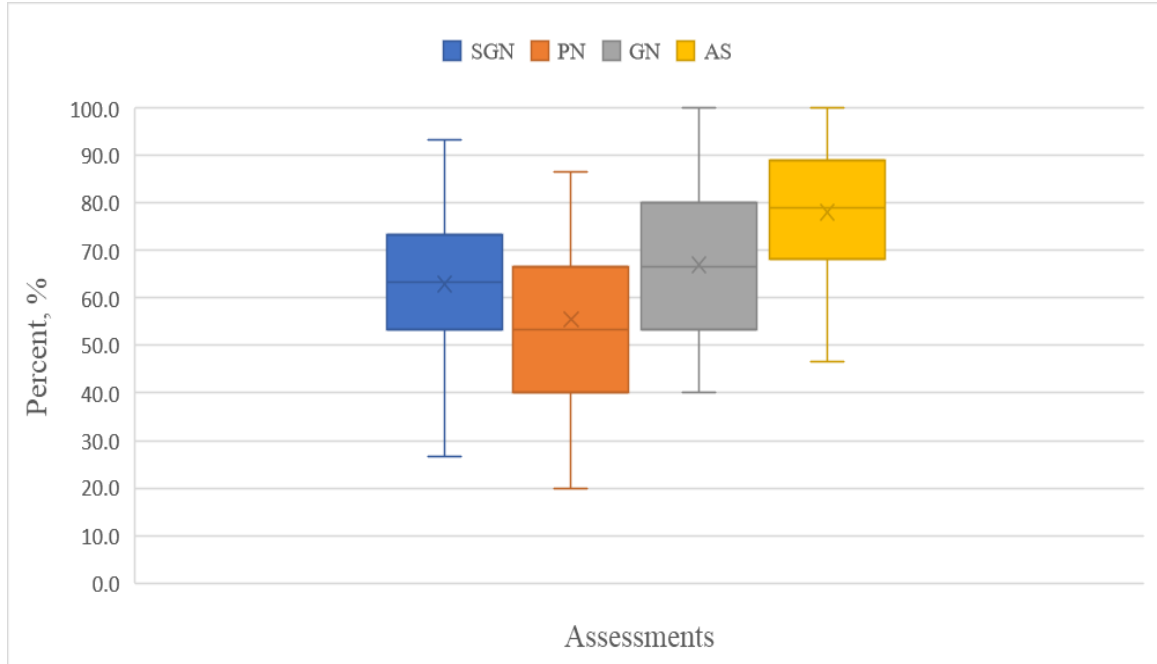


Figure 4. Student percent correct for the post-assessments and summative assessment, ($N=53$).

According to the data, the mean for post-assessment two (PN) was about ten percent lower than post-assessment one (SGN). I assume the students did not take the studying for the assessment seriously. The post-assessment was based on the partial notes. We see a four percent increase in the mean for post-assessment three (GN) over post-assessment one and there is a significant increase in mean between the summative assessment (AS) and post-assessment one. Again, guided notes should have given the students a better canvas from which to study. Looking at the quartiles of post-assessment one, we see most of the student means fall in the third quartile as compared to the other three assessments, where the means are fairly distributed between the first and third quartile. As stated in the methodology of the paper, each post-assessment consisted of fifteen questions. The summative assessment consisted of forty-five questions, fifteen questions for each of the concept areas. In Figure 5, there is a comparison of the mean

for percent correct of the fifteen questions from the post-assessment versus the mean for percent correct of the fifteen questions from the summative assessment that go with the particular concepts.

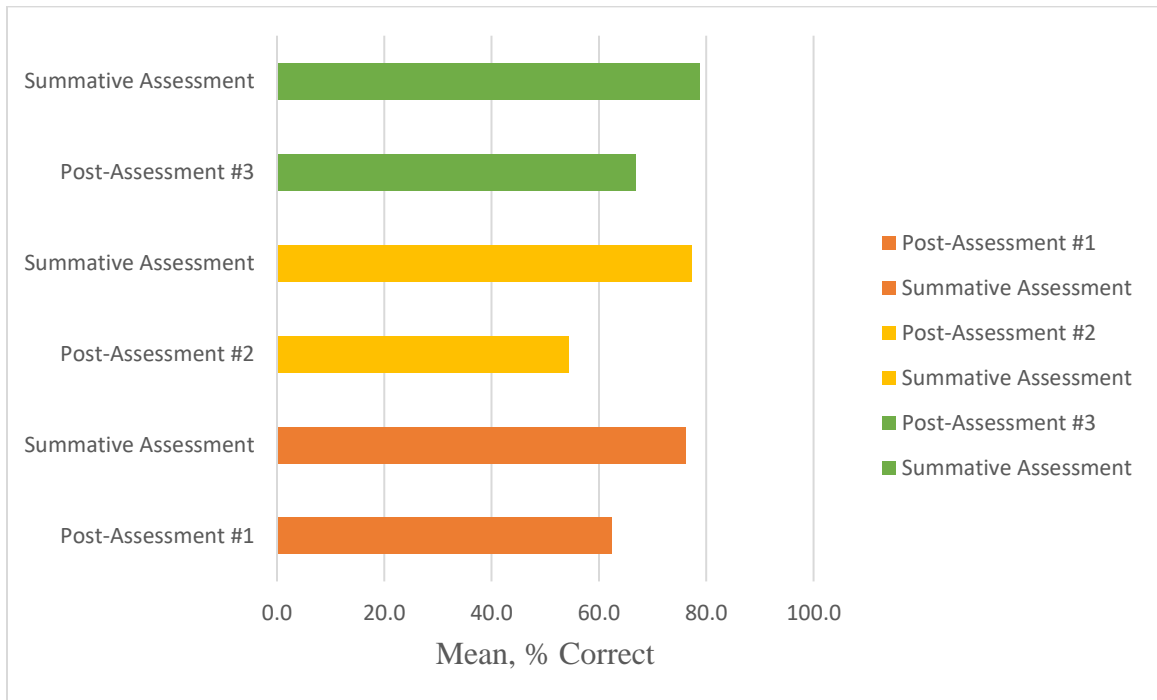


Figure 5. Means of percent correct of fifteen questions on post-assessment versus means of percent correct of fifteen questions on summative assessment, ($N=53$).

As we see, the data shows an increase in the percent correct in each section of the summative assessment over each of its corresponding post-assessment. The overall mean of percent correct on the summative was seventy-eight percent and the means for the three-section averaged between seventy-six and seventy-nine percent. So, there was not one section that outweigh another section. A definite improvement in student scores is seen for the summative assessment over the post-assessments.

INTERPRETATION AND CONCLUSION

What effect can note taking strategies have on student's retention of science concepts and is one strategy better than another? These were the underlying premises of this project. Research claims that different note taking strategies can influence student retention. Since the seventies, the research into note taking has taken an analytical approach. Most notetaking research deals with the cognitive aspect of note taking, things like working memory, encoding, and external storage. When it comes to actual strategies of note taking, most research deals with student-generated and teacher-generated (partial, complete, and guided). I used student-generated, partial (fill in the blank), and guided notes for this research project. The project coincided with my unit on Earth's Oceans. The unit was broken up into three parts: ocean characteristics, seawater composition, and ocean circulation, currents, and tides. In each section one of the note taking strategies was used. A pre-assessment was given prior to and a post-assessment was given after the note taking strategy was used. At the end of the treatment, the summative assessment was given (Appendix K).

Based on the quantitative data gathered throughout the study, there were only slight differences in the student's retention with the use of the different strategies. Just based on the percent correct data, the guided notes were the best strategy. Even though it was not as high as I expected, the sixty-seven percent correct was an improvement over sixty-three for student-generated and fifty-six for partial notes. The pre-assessments (Appendices C, E, H) were set up as misconception probes based on popular misconceptions of our oceans. For pre-assessment one and three, the correct answer to

the statement was disagree. I used them to adjust my lecture material. The students chose either disagree or agree based on their prior knowledge. Pre-assessments one and three each had two statements that had about a 1:1 ratio of disagree to agree. For pre-assessment two, students chose a student's statement. Trinh's statement, which was incorrect, was picked by fifty-three of the students. Heather's, the correct statement, was chosen by thirty-nine percent. The statements from the pre-assessment were emphasized during the lecture, in which the students used the student-generated strategy (Appendix L). The students could take the notes anyway they wanted to. There were parts of the lecture not on the presentations that I just talked about. It was the hope students would write down this information with seeing it on the screen. Four questions on the post-assessment were geared towards this. Three of those were answered correctly by sixty percent or less of the class. A few days after the lecture, the post-assessment was given. Students had to study just using their notes. The mean for the assessment was sixty-three percent. Question three on the post-assessment, which seventy percent answered correctly, coincides with statement three on the pre-assessment, where fifty-five answered correctly. That is about a twenty percent improvement from the pre-assessment. The same question on the summative was answered correctly by seventy-four percent. The overall average for the pre-assessment was lower than expected. I believe student struggle with student-generated because they either try to write everything or they are not sure what is important. Based on observations made in my teacher journal, thirty-five students had incomplete notes and fourteen did not turn in their notebooks so I am not sure of how complete their notes were.

Partial notes are also called fill in the blank notes. Student are given a packet with incomplete notes and diagrams (Appendix F). As the lecture proceeds, students fill in information on blank lines or diagrams. This way the student's attention is more focused or at least that is the hope. This note taking strategy was used with the seawater composition segment of the unit. As stated above, the data for this segment's pre-assessment was Trinh's conception was fifty-three percent and thirty-nine percent for Heather's conception (Appendix G). Trinh believes the salt comes from the sediment and rock on the ocean floor and Heather believes it comes from the dissolving of rocks and soil due to acid rain and runoff. Heather has the correct reasoning. As with the student-generated note, we proceeded through the lecture and students took the notes. At the end of lecture, note packets were collected, looked over by me, select pictures taken, and returned the following day. The post-assessment was given a few days later. The partial notes strategy did not do as well as the student-generated notes. They both had low percentages. The partial notes post-assessment had a mean of fifty-six percent compared to the sixty-three for student generated. Question four of the post-assessment were similar to Heather's conception. This question was answered correctly by fifty-nine percent of the students, one of the lower percent questions on the entire assessment. The surprise came from the data for the similar question on the summative assessment. Question nineteen was answered one hundred percent correctly. It was the wording of the question on the summative that made the difference. Since the student-generated notes data was used as a baseline, I ran a paired t-test with those results against the result of the assessment from the partial notes. If we look back at table three in the data

analysis section, the p-Value for the test was 0.004. Based on this number, the partial note taking strategy was not as strong of a strategy as one would think. I believed partial notes would show an improve in students' retention over the student-generated notes.

The final note taking strategy was guided notes. I created symbols or icons and added the into my presentation (Appendix I). The advantage of the symbols is to help the students with the note taking process. This part of the unit was broken up into three parts: circulation, currents, and tides. The pre-assessment for this strategy was set up just like pre-assessment one (Appendix H). It consisted of five common misconceptions with a disagree or agree answer choice. And just like the first pre-assessment, two misconceptions stand out. Statement two, which was sixty-four percent disagree and thirty-six percent agree. Statement five was more a 1:1 ratio with fifty-three choosing disagree and forty-seven chose agree. Statement two dealt with the ocean currents being caused by tides. On the post-assessment, question one deals with this misconception and a disappointing thirty-nine percent answer it correctly. The prevailing winds are the main driving force of surface currents. The Coriolis Effect, caused by Earth's rotation, also influences currents. It deflects currents clockwise in the Northern Hemisphere and counter-clockwise in the Southern Hemisphere. For question one, Coriolis Effect was one of the answer choices, which was the most common wrong answer for the assessment. Question twelve can also be related the misconception. It deals more with the aspect of tides. If students understood the principles of tides, they should have known tides do not influence currents. This question was answered correctly by ninety-four percent of the students. With the summative assessment (Appendix K), questions six and

thirty are related to the pre- and post-assessments. According to the data, question six was answered correctly by eighty-one percent and question thirty was answered correctly by ninety-six percent. So, a definite improvement over the pre- and post-assessments. Statement five of the pre-assessment deals with whether climate is controlled by wind and sunlight or ocean currents and sea-surface temperatures. It is ocean currents and sea-surface temperatures that are the driving force of climate. On the post-assessment and the summative assessment there are no direct questions to this concept. Questions four and eleven on the pre-assessment and question thirty-one on the summative are testing the critical thinking skills of the students. On both the post- and summative assessment we can see improvement over the pre-assessment. Question four had seventy-two percent, question eleven had one hundred percent, and question thirty-one had ninety-eight percent of the students answer correctly. A t-test was also done with for the comparison of post-assessment one and three. The result of 0.056 was higher than the previous t-test run. In the case of student-generated notes versus guided notes, the t-test showed by chance guided notes are slightly better for the students than student-generated notes. We can also look at my teacher journal for some evidence. Looking through the collected notebooks there was improvement in the guided note taking as compared to the student-generated. Twelve students had completed notes, meaning, they had all diagrams drawn and labeled and the key concepts highlighted. With the student-generated, I only had four completed notebooks.

This research project used three different note taking strategies to see if one or all helped students with their retention of science concepts. Is the effect of the different

strategies strong enough to pick one over another? Overall, using the student-generated notes as a baseline, we see the guided notes seem to have helped the most. It was not a significant change over the other two though. Looking back a figure five and table three, we see a seven and a half percent difference between student-generated to partial and a four percent difference between student-generated to guided. The data is not strong enough to say one strategy is better than another. I believe there are other circumstance that hindered the study based on observations made throughout the project. Observations were made in my teacher journal (Appendix M). The first was not every student participated in the note taking process. Notebook or note packets were collected after the strategy was implemented. The first strategy, student-generated, four students had completed the notes, twenty-four were missing parts here and there, around eleven students had incomplete notes, either half or quarter of them, and several did not turn in anything at all. The participation with partial notes strategy was better. The main thing here was not completing the diagram, which was around twenty-eight out of fifty-three were incomplete. The guided notes were about the same as the student-generated, slightly better though. Most my students are seniors and second semester is when they start to shut down. Another observation is based on our grading scale. The post-assessments, which are quizzes in my student eyes, are daily grade and only account for ten percent of the grade. The summative assessment is a major grade that accounts for fifty percent of the grade. So, the students are going to put forth more effort studying for the summative than the post-assessments. There was a difference in the range of eleven to twenty-two percent between the post-assessments and summative. Prior to the taking

of the summative, I noticed students taking pictures of the completed notes books. A final observation is our students are used to having a review guide for their tests or summative assessments. I am just as guilty as the other teachers, not just science, at giving out review guides instead of studying their notes. My had to adjust for this research project and I do not think it was easy. Overall, is it decisive to say one strategy is stronger than another. Based on data and observations made, I am going to say no.

VALUES

What can be changed? What will be used in future classes? What is the impact on the teacher? These are just a few questions that are popping into my mind. One of the big changes would be doing a couple more cycles of the treatments. Due to time constraints like waiting on approval to conduct the study and my own procrastination, I would collect more data to see if one strategy is better than another. I would also develop expectations at the beginning of the year for note taking practices. Based on observation made in my journal, if partial notes are used there should be a specific set of expectations like diagrams need to be labeled. That was the biggest issue with my students. Thirty out of fifty-three left the diagrams blank. I also think incorporating the guided note symbols into the partial notes would increase their effectiveness. The guided notes also need a set of expectations. The main one being highlighting key concepts. Both these note taking strategies can be beneficial to my students and make me feel confident my students are getting the most out of my lectures. Once they are set up, it should also make my life easier. This study was also conducted with just my upper level students. It might be interesting to include my on-level students in the research. In all reality, these

strategies would be more effective with my on-level students. One strategy I will incorporate more into future lectures are the guided notes. Based on the little data I have and other circumstances, the guided notes seem to have the most significance of the three strategies. With a little work, I believe they could be a benefit to the students and their overall retention. Another item from the study I will continue to use on a regular basis is the pre- and post-assessments. I have used them in the past but not all the time. The pre-assessment gives me a view of students' prior knowledge and any misconceptions they have. This will allow me to adjust my lectures accordingly. The post-assessments will show the students the areas they are struggling and the need to study a little harder. The data from the post assessments can show the need for re-teaching or if enrichment activities for certain concepts are needed.

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APPENDICES

APPENDIX A
CFISD DEPARTMENT OF SCHOOL IMPROVEMENT
AND ACCOUNTIBILITY MEMO



Cypress-Fairbanks Independent School District

Department of School Improvement and Accountability

Dr. Christy Dafonte
Research Specialist

To: Timothy Ferrigan
From: Christy Dafonte, Ed.D.
Cc: Scott Vanderzyden, Ralph Funk
Date: February 28, 2019
Re: Approval of Application to Conduct Research in Cypress-Fairbanks ISD

Your request to conduct the research project titled: *The Effects of Note Taking Strategies on Retention of Science Content on High School Students*, has been approved for Cypress-Fairbanks ISD.

As you pursue this project, please refer to the conditions listed below:

General Conditions:

- ⊙ Keep Ralph Funk, Principal of Jersey Village High School, informed of all activities involved with the project.
- ⊙ You are approved to conduct your research only on the following campus: Jersey Village
- ⊙ As your research sponsor, Scott Vanderzyden will assist you in the following manner:
 - Sending consent forms to parents of the researcher's Earth Space Science students. The forms will only be sent home once. If parents do not respond, they will not be contacted a second time.
 - Consent forms should be returned to Scott Vanderzyden. He will provide you with the consent forms of those individuals who consent to participate in your study. At that point, Timothy may contact the participants to administer your surveys.
 - Timothy may not start any part of his research or data collection until consent to participate has been received by Scott Vanderzyden.
- ⊙ Interviews can be **audio recorded only**. No videotaping allowed.
- ⊙ The researcher cannot interview students by himself. There must be other students or an adult present during all interviews.
- ⊙ For any assessments which are used as course grades, the students must be allowed the opportunity to retest per the campus testing policy.
- ⊙ Practice confidentiality while conducting the various steps necessary to complete the project.
- ⊙ Use a pseudonym instead of actual names of campuses or personnel in your research report.
- ⊙ No additional data may be collected beyond the survey and interview responses, pre/post assessments, summative assessment, and teacher journals.
- ⊙ Use a random code system to record data collected. Never use actual names, ID, or social security numbers.

10300 Jones Road, Houston, Texas 77065
281.897.4000

P.O. Box 692003
Houston, Texas 77269-2003

APPENDIX B

MONTANA STATE UNIVERSITY IRB MEMO



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MEMORANDUM

TO: Timothy Ferrigan and Walt Woolbaugh

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

DATE: March 25, 2019

RE: "The Effects of Note Taking Strategies on Retention of Science Content on High School Students" [TF032519-EX]

The above research, described in your submission of March 23, 2019, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

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

APPENDIX C

PRE-ASSESSMENT – OCEANS/OCEAN CHARACTERISTICS

Pre-Assessment
Misconception Probe
Oceans/Ocean Characteristics

Read the following statements. If you agree with the statement, circle agree. If you disagree with the statement, circle disagree. Then explain why you chose to agree or disagree with the statement.

1. The oceans are the deepest in the middle. Agree Disagree
Why?
2. The seafloor is flat. Agree Disagree
Why?
3. The ocean is blue from sky reflection. Agree Disagree
Why?
4. The oceans are separate and not connected. Agree Disagree
Why?
5. The terms “ocean” and “sea” can be used interchangeably when talking about the ocean. There is no difference between the two. Agree Disagree
Why?

APPENDIX D

POST-ASSESSMENT – OCEANS/OCEAN CHARACTERISTICS

Oceans Quiz

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 1. Our oceans appear bluish-green to blue due to the _____
a. reflection of our blue skies c. absorption of white light
b. green and blue algae d. color of ocean floor
- _____ 2. The northern hemisphere is comprised of 39% land. What is another name for this hemisphere?
a. Land c. North America
b. Northern d. Water
- _____ 3. These two oceans occur mostly in the Southern Hemisphere.
a. Houston and Dallas c. Southern and Arctic
b. Indian and Southern d. Atlantic and Indian
- _____ 4. The science that unravels the mysteries of the oceans, a combination of the chemical, physical, geological, and biological sciences is called _____
a. Marine Science c. Psychology
b. Chemistry d. Oceanography
- _____ 5. Earth's water is divided into 4 areas. Saltwater is the largest at 97%. What is the second largest at 2%?
a. Groundwater c. Ice
b. Water Vapor d. Freshwater
- _____ 6. What wavelength of light is absorbed in the first meter of water?
a. blue c. yellow
b. red d. green
- _____ 7. The zone where most ocean life resides and is deepest in the tropics is called?
a. Aphotic Zone c. Bathypelagic Zone
b. Abyssopelagic Zone d. Photic Zone

- ___ 8. What percent of the earth's surface is covered with water?
- | | |
|--------|--------|
| a. 23% | c. 76% |
| b. 50% | d. 71% |

Matching

Write the letter of the ocean that best matches the description. Answers may be used more than once.

- | | |
|-------------|-------------|
| a. Arctic | d. Pacific |
| b. Atlantic | e. Southern |
| c. Indian | |

- ___ 9. Covered with sea ice most of the year
- ___ 10. Smallest of the 5 oceans
- ___ 11. Mariana Trench
- ___ 12. Holds 26% of Earth's ocean water
- ___ 13. Begins at a latitude of 60 degrees S
- ___ 14. Mountain building along plate margins
- ___ 15. Large sediment deposits from rivers

APPENDIX E

PRE-ASSESSMENT – SEAWATER COMPOSITION

Pre-Assessment
Misconception Probe
Seawater Composition

TABLE SALT + H₂O = SEAWATER



Mr. Ferrigan's ESS class takes a field trip to Galveston Island to study the effects of wave erosion on the beaches. A group of students are sitting on the beach watching the wave action and begin discussing the saltiness of the water. Each student has a different conception on where the salt comes from to create saltwater.

Ben: He thinks the salt has always been there since the oceans were formed on the earth.

Jose: He thinks it comes from and moves around through the water cycle

Heather: She thinks it comes from the dissolving of rocks and soil due to acid rain and runoff.

Ali: He thinks it comes from the coral reefs on the bottom of the ocean floor.

Trinh: She thinks it is from the sediment and rock on the ocean floor.

Rocky: He thinks it comes from the melting of icebergs and sea ice.

Who do you think has the best idea? _____
Explain your thinking.

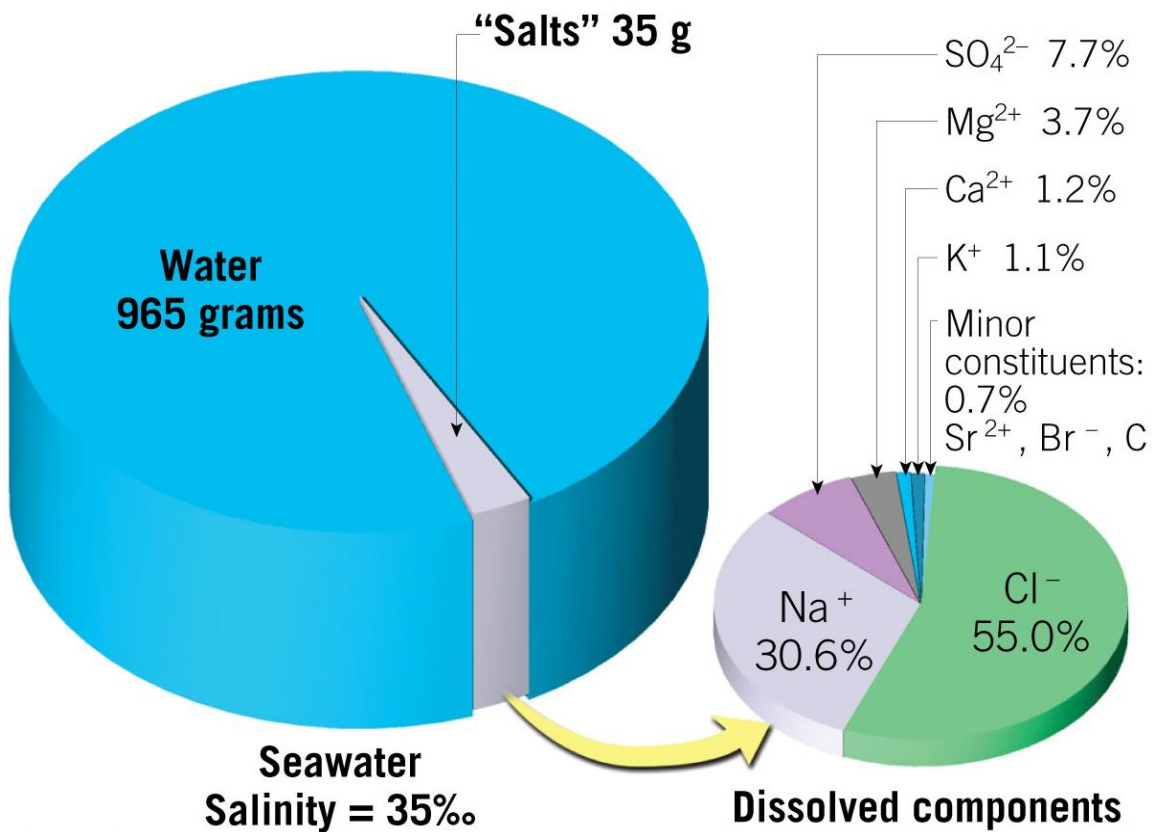
APPENDIX F

PARTIAL NOTES – SEAWATER COMPOSITION

Seawater Composition Notes

Composition of Seawater

- Seawater consists of about _____ dissolved minerals
- Salinity
 - Total amount of _____ dissolved in water
 - Typically expressed in _____ or ppt
 - Average salinity is _____
 - Major constituent is _____
- Dissolved Components of Seawater – these are in the form of ions.

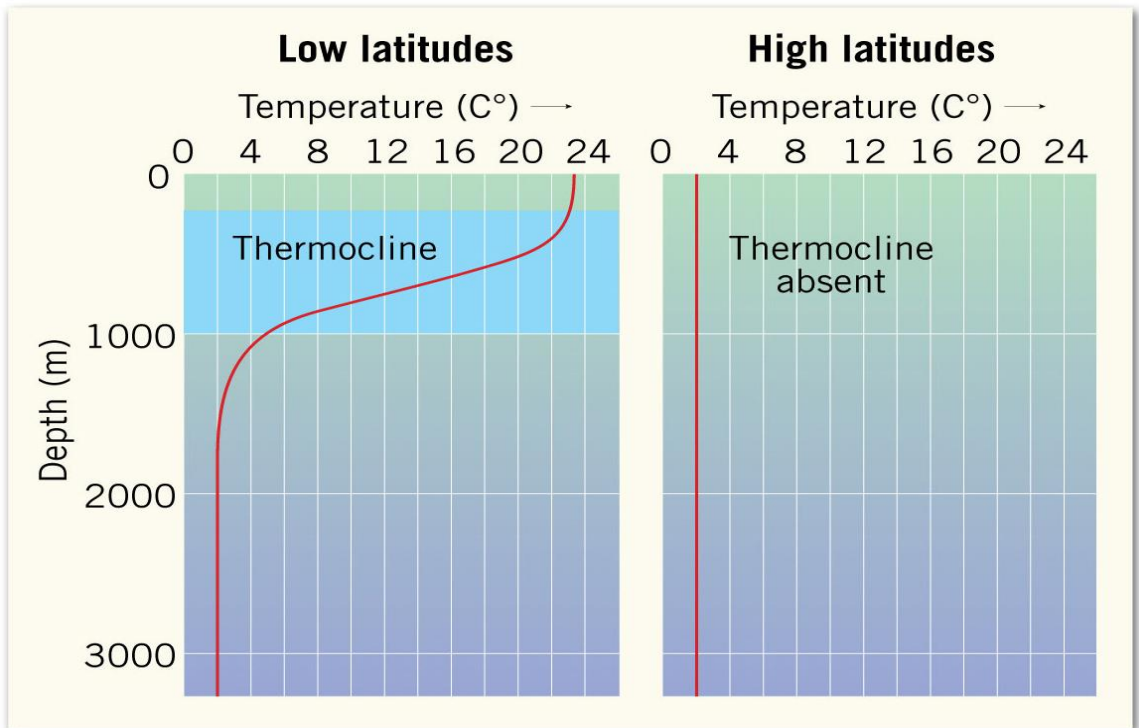


- Sources of sea salts
 - _____
 - Outgassing – _____
- Processes affecting seawater salinity
 - Variations in salinity are a consequence of changes in _____
- Processes affecting seawater salinity
 - Processes that decrease salinity _____
 - _____
 - _____
 - _____
 - _____
 - Processes that increase salinity _____
 - Evaporation
 - Formation of sea ice
 - Surface salinity in the open ocean ranges from 33ppt to 38ppt
- Looking at the Surface Salinity of our oceans, we can identify 2 areas of low salinity and an area of high salinity
 - _____
 - _____

– _____

Ocean Temperature

- Surface water temperature varies with the amount of _____
 - Lower surface temperatures are found in _____
 - Higher temperatures found in _____
- Temperature variation with depth
 - Low-latitudes
 - High temperature at the surface
 - Rapid decrease in temperature with depth _____
 - High-latitudes
 - Cooler surface temperatures
 - _____

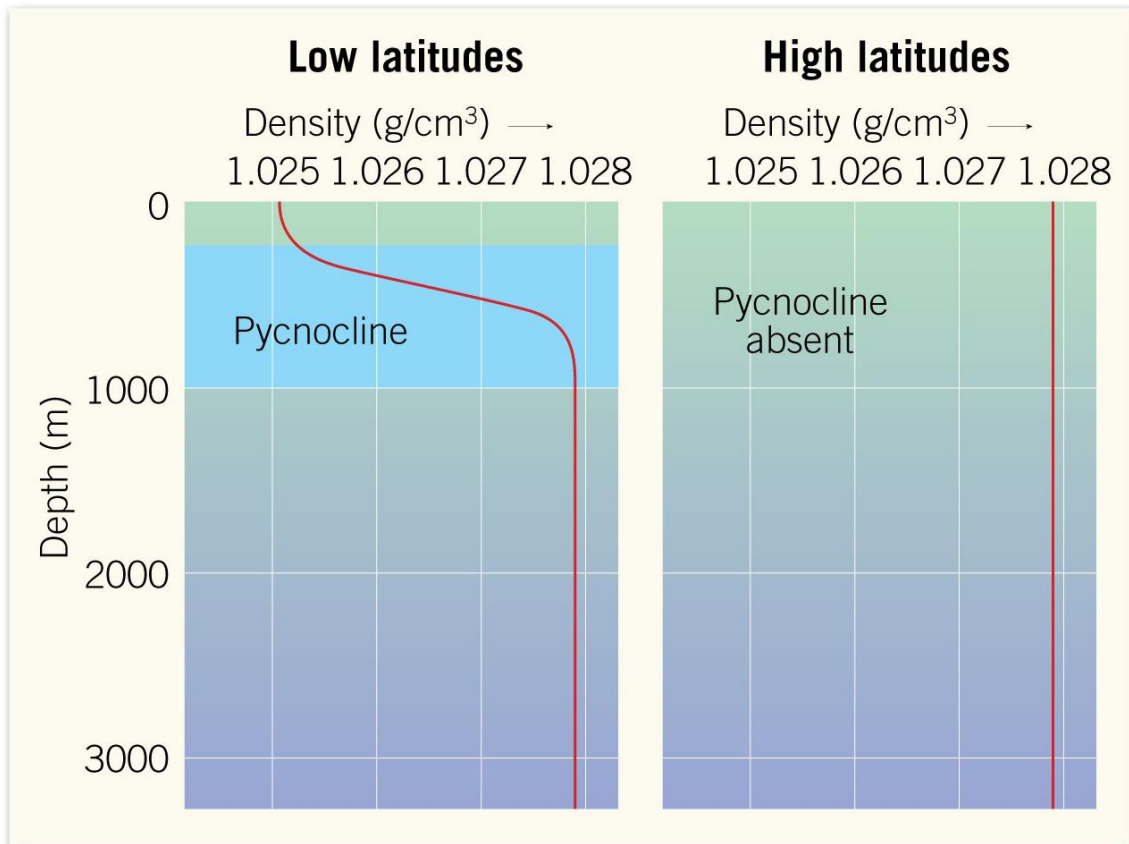


- Ocean temperature over time
 - The unique thermal properties of seawater make it resistant to temperature changes
 - Global warming could eventually influence ocean temperatures

- Variations in surface temperature and salinity with latitude. List the temperature and salinity at the following latitudes.
 - 60⁰N _____
 - 20-30⁰N & S _____
 - 60⁰S _____
 - 0⁰ _____

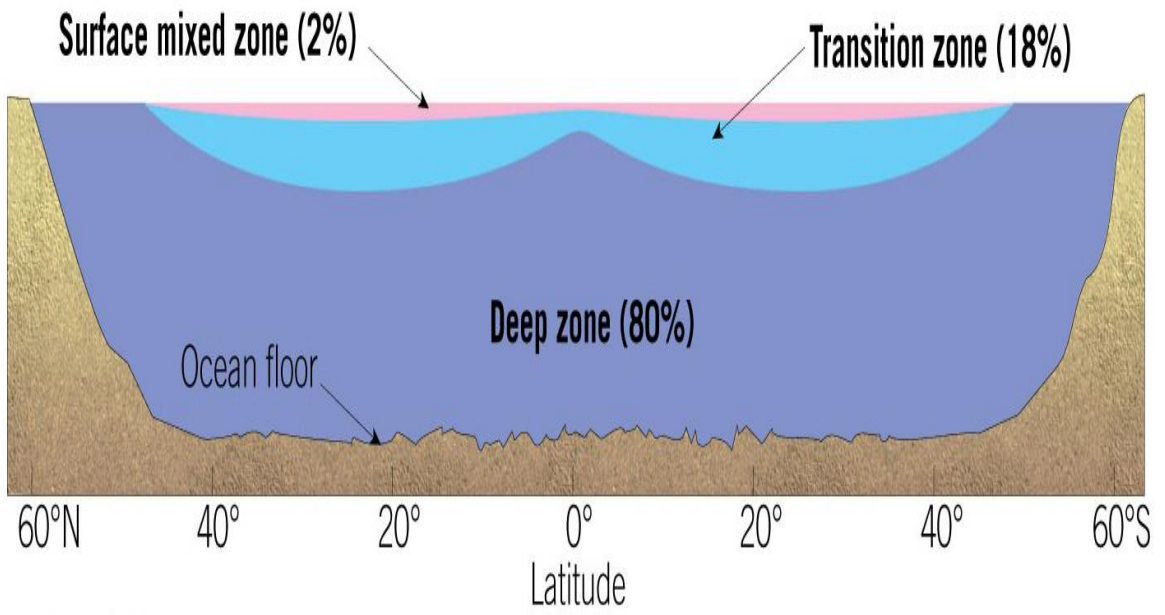
Ocean Density

- Density is mass per unit volume – _____
- Determines the water's vertical position in the ocean
- Factors affecting seawater density
 - _____
 - _____
- Variations with depth
 - Low-latitudes
 - _____
 - Density increases rapidly with depth _____ because
of colder water
 - High-latitudes
 - _____
 - _____



- Ocean layering
 - Layered according to _____
 - Three-layered structure
 - Surface mixed zone
 - _____
 - _____
 - _____
 - Transition zone
 - Between surface layer and deep zone

- Deep zone



APPENDIX G

POST-ASSESSMENT – SEAWATER COMPOSITION

Seawater Composition Post-Assessment

1. The average salinity of seawater is _____.
 - A) 0.01%
 - B) 0.27%
 - C) 3.5%
 - D) 19.8%
 - E) 30.0%
2. The proportion of dissolved substances in seawater is expressed as 0/00, which is the same as _____.
 - A) Parts per hundred
 - B) Parts per thousand
 - C) Parts per million
 - D) Parts per billion
3. The most abundant salt in seawater is _____.
 - A) KCl
 - B) $MgCl_2$
 - C) NaCl
 - D) SiO_2
4. The dissolved materials in seawater are thought to originate from chemical weathering of rocks on the continents and from _____.
 - A) Organisms
 - B) Evaporation of fresh water
 - C) Erosion
 - D) Outgassing of elements from Earth's interior
 - E) Meteorites
5. Which of the following is **not** a process that removes dissolved components from seawater?
 - A) Evaporation
 - B) Chemical precipitation
 - C) Organisms building hard parts
 - D) Hydrothermal activity
 - E) All the above remove components from seawater.
6. Salinity in the ocean is highest in regions where _____ is high and _____ is low.
 - A) Evaporation; precipitation
 - B) Precipitation; evaporation
 - C) Temperature; evaporation

D) Precipitation; temperature

7. The total amount of solid material dissolved in water is known as _____.
- A) load
 - B) salinity
 - C) solute
 - D) insoluble residue
8. In tropical regions the surface temperature of the oceans is high but decreases rapidly with depth between 300 and 1000 meters because _____.
- A) Rapidly upwelling cold currents occur in these regions
 - B) Cold water from the Polar Regions flows just below the surface
 - C) Volcanic activity on the seafloor is rare in the tropics
 - D) Sunlight cannot penetrate much below the surface of the oceans
 - E) Tropical regions are areas of high rainfall and this rapidly lowers the temperature of seawater
9. Temperatures in the deep oceans are _____ at low latitudes compared to high latitudes.
- A) Higher
 - B) Lower
 - C) About the same
 - D) Highly variable
 - E) Very constant
10. Density is an important property of ocean water because _____.
- A) It determines the chemistry of the water
 - B) It determines the horizontal position of the water
 - C) It determines the temperature of the water
 - D) It determines the vertical position of the water
 - E) It only changes when there is a major change in water chemistry
11. Thermoclines in the ocean are best developed at _____.
- A) lower latitudes
 - B) higher latitudes
 - C) both high and low latitudes
 - D) regions close to continents
12. At high latitudes the thermocline is _____.
- A) narrower than at low latitudes
 - B) wider than at low latitudes
 - C) about the same as at low latitudes
 - D) There is no thermocline at high latitudes.

E) There is no thermocline at low latitudes.

13. The *surface mixed zone* is characterized by _____.

A) nearly constant temperatures to a depth of about 300 meters

B) a rapid change from warm temperatures on top to cold temperatures at a depth of about 300 meters

C) high density water near the surface that rapidly decreases in density with depth

D) low density water near the surface that rapidly increases in density with depth

E) a mixture of temperatures and densities to a depth of about 300 to 450 meters in depth.

14. The *deep zone* makes up about 80% of the ocean waters and it is characterized by _____.

A) water that gradually decreases in temperature and density with depth

B) water that gradually increases in temperature and density with depth

C) water that gradually increases in temperature and decreases in density with depth

D) water that gradually decreases in temperature and increases in density with depth

E) water with relatively uniform temperature and density throughout

15. Density in seawater is determined by _____.

A) temperature

B) salinity

C) both temperature and salinity

D) none of these

APPENDIX H

PRE-ASSESSMENT – OCEAN CIRCULATION, CURRENTS, & TIDES

Pre-Assessment
Misconception Probe
Ocean Circulation/Tides/Currents

Read the following statements. If you agree with the statement, circle agree. If you disagree with the statement, circle disagree and explain why you disagree.

1. Tides are caused by Earth's rotation . Agree Disagree

Why?

2. The ocean currents are caused by the tides. Agree Disagree

Why?

3. The deep parts of the ocean are stagnant, never change. Agree Disagree

Why?

4. Currents in the Northern and Southern hemispheres run in the same direction.

Agree Disagree

Why?

5. Winds and sunlight control the climate much more than the ocean currents or sea-surface temperatures.

Agree Disagree

Why?

APPENDIX I
GUIDED NOTES SYMBOLS

Guides Notes Symbols



Pencils Down and Listen



Any questions at this point



Key Ideas – Previous Slide (Highlight or Circle)



Write down Information



Answer the Following Question/Questions in Notebook



Draw the Diagram

APPENDIX J

POST-ASSESSMENT – OCEAN CIRCULATION, CURRENTS, & TIDES

Circulation/Tides/Currents Post-Assessment

1. The energy that drives surface ocean currents such as the Gulf Stream comes from _____.
 - A) Salinity variations
 - B) Coriolis Effect
 - C) Prevailing winds
 - D) Density differences

2. A poleward-moving ocean current is _____.
 - A) Warm
 - B) Cold
 - C) Warm only in the Northern Hemisphere
 - D) Warm only in the Southern Hemisphere

3. Because of the Coriolis Effect, surface ocean currents are deflected to the _____ of their path of motion in the Northern Hemisphere.
 - A) Right
 - B) Left
 - C) West
 - D) East

4. Coastal California is famous for fog. Why is the California coast foggy, whereas Houston, Texas, which is at similar latitude, but fog is relatively rare?
 - A) Cold currents along the Texas coast inhibit fog, whereas the ocean is warm off California.
 - B) The ocean is warm off the Texas coast, but a cold current running offshore California generates fog when the cold, moist air is drawn ashore by a sea breeze.
 - C) There isn't really any fog; it is all just smog from too many cars in California.
 - D) Warm air in Texas rises to make clouds and not fog, whereas in California cold water from the ocean mixes with warm water from the land to generate fog.

5. Thermohaline circulation is _____.
 - A) Shallow circulation at low latitudes driven by surface evaporation making seawater denser, which then sinks and drives upwelling
 - B) Deep circulation of water driven entirely by cold, saline water descending to the ocean floor at the poles and flowing along the bottom of the ocean
 - C) Deep circulation of water driven by a combination of cold temperature and high density related to high salinity from formation of sea ice, producing descending high-density waters that flow southward to equatorial regions
 - D) The circulation that occurs in shallow, evaporate basins when salt begins to crystallize, releasing heat by latent heat of fusion and heating the water mass, forcing shallow convection in the water column

6. Which of the following is a tidal current?
- A) Spring tide
 - B) Flood tide
 - C) Ebb tide
 - D) Both flood and ebb tide
7. The daily tidal range is GREATEST during what period of the lunar cycle?
- A) Full moon
 - B) First quarter
 - C) New moon
 - D) A and C
8. When the daily tidal range is LEAST, it is called a _____ tide.
- A) Spring
 - B) Ebb
 - C) Neap
 - D) None of these
9. A spring tide occurs _____.
- A) Once a year at the first full moon after the vernal equinox
 - B) Twice a year at the new or full moon closest to the vernal and autumnal equinox
 - C) About 26 times per year, at every full and new moon
 - D) Once a month, or 12 times a year
10. A La Nina condition is trigger when an increase in cold water move across the surface from the coast of South America. The force that moves the cold water from the deep ocean to the surface is called.
- A) Down drafting
 - B) Upwelling
 - C) Surface currents
 - D) Flooding
11. Ocean circulation is important for the following reasons:
- A) Influences Earth's climate and weather
 - B) Transports nutrients and organisms
 - C) Transports heat from the equator to the poles
 - D) All the above reasons
12. The tides are most strongly influenced by the _____.
- A) Earth's rotation
 - B) Wind
 - C) Moon

D) Sun

13. Due to the Coriolis Effect, ocean gyres in the Southern Hemisphere rotate in what direction?

- A) Clockwise
- B) Up and down
- C) No rotation at all
- D) Counter-clockwise

14. Which 2 currents circumvent (circle) the Earth without any interference from landmasses?

- A) E. Greenland Current
- B) Southern Current
- C) North & South Equatorial
- D) East & West Wind Drift

15. When Europeans first came to the new world they would typically sail south and west to Canary Islands, then sail west to get to the West Indies and Spanish main. On their return, however, they would go north to the "Leeward Islands" of the Caribbean, to the Bahamas, Bermuda, etc. Why did they take this odd route rather than sail straight?

- A) The ships were affected by the Coriolis effect, so this was the natural route.
- B) Although this route was against the ocean currents, it followed the prevailing wind direction so sailing ships could follow this route downwind—hence the name "Leeward Islands."
- C) They were attempting to follow the shortest distance, via what is called a great circle route.
- D) This route followed both the prevailing winds and ocean currents, speeding the trip despite longer distances.

APPENDIX K
SUMMATIVE ASSESSMENT

Oceans Summative Assessment 2019

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 1. Earth's water is divided into 4 areas. Saltwater is the largest at 97%. What is the second largest at 2%?
- | | |
|----------------|---------------|
| a. Groundwater | c. Ice |
| b. Water Vapor | d. Freshwater |
- _____ 2. What percent of the earth's surface is covered with water?
- | | |
|--------|--------|
| a. 23% | c. 76% |
| b. 50% | d. 71% |
- _____ 3. Due to the Coriolis Effect, ocean gyres in the Southern Hemisphere rotate in what direction?
- | | |
|----------------|----------------------|
| a. Clockwise | c. No rotation |
| b. Up and down | d. Counter-clockwise |
- _____ 4. The place where warm water rapidly changes to cold water is the _____.
- | | |
|---------------|----------------|
| a. Volcano | c. Thermocline |
| b. Cold abyss | d. Drop zone |
- _____ 5. Salinity in the ocean is highest in regions where _____ is high and _____ is low.
- | | |
|-------------------------------|-------------------------------|
| a. Evaporation; precipitation | c. Temperature; evaporation |
| b. Precipitation; evaporation | d. Precipitation; temperature |
- _____ 6. The energy that drives surface ocean currents such as the Gulf Stream comes from _____.
- | | |
|------------------------|------------------------|
| a. Salinity variations | c. Prevailing winds |
| b. Coriolis Effect | d. Density differences |
- _____ 7. The science that unravels the mysteries of the oceans, a combination of the chemical, physical, geological, and biological sciences is called _____.
- | | |
|-------------------|-----------------|
| a. Marine Science | c. Psychology |
| b. Chemistry | d. Oceanography |

- _____ 8. The difference in levels of ocean water between high and low tides is known as a:
- a. Tidal bore
 - b. Tsunami
 - c. Tidal range
 - d. Spring tide
- _____ 9. Thermohaline Circulation is the other name for _____?
- a. Surface currents
 - b. Wind driven currents
 - c. Coriolis Effect
 - d. Deep ocean circulation
- _____ 10. The northern hemisphere is comprised of 39% land. What is another name for this hemisphere?
- a. Land
 - b. Northern
 - c. North America
 - d. Water
- _____ 11. The temperature of the surface varies due to the amount of _____ it receives.
- a. Solar radiation
 - b. Pollution
 - c. Fresh water
 - d. Nano probes
- _____ 12. An ocean current moving from the poles towards the equator is _____.
- a. Warm
 - b. Cold
 - c. Warm only in the Northern Hemisphere
 - d. Warm only in the Southern Hemisphere
- _____ 13. A La Nina condition is trigger when an increase in cold water move across the surface from the coast of South America. The force that moves the cold water from the deep ocean to the surface is called.
- a. Upwelling
 - b. Down drafting
 - c. Surface currents
 - d. Flooding
- _____ 14. Different salts/mineral make up the salinity of our oceans. Which salt constitutes the largest percent (about 2.4%) in our oceans?
- a. KCl
 - b. CaCl
 - c. NaCl
 - d. MgCl₂

- ___ 31. Ocean circulation is important for the following reasons.
- | | |
|---|---|
| a. Influences Earth's climate and weather | c. Trans ports heat from equator to the poles |
| b. Transports nutrients and organisms | d. All the above reasons |
- ___ 32. Because of the Coriolis Effect, surface ocean currents are deflected to the _____ of their path of motion in the Northern Hemisphere.
- | | |
|----------|---------|
| a. Right | c. Left |
| b. Up | d. Down |
- ___ 33. What ocean is the largest, contains 52% of ocean water, and has an average depth of 13,000 ft.?
- | | |
|-------------------|------------|
| a. Atlantic | c. Indian |
| b. Gulf of Mexico | d. Pacific |
- ___ 34. The density of the ocean water is dependent on two factors:
- | | |
|-----------------------------|--------------------------------|
| a. Salinity and composition | c. Temperature and composition |
| b. Salinity and size | d. Temperature and salinity |

Multiple Response

Identify one or more choices that best complete the statement or answer the question.

- ___ 35. What 2 currents can circumvent the Earth without any interference from landmasses? (use diagrams provided)
- | | |
|-------------------------|---------------------|
| a. East Wind Drift | c. Southern current |
| b. E. Greenland current | d. West Wind Drift |
- ___ 36. Which of the following are warm water currents? **(use diagrams provided)**
- | | |
|-----------------------|------------------|
| a. N. & S. Equatorial | c. Brazil |
| b. Kuroshio | d. W. Australian |
- ___ 37. The gyres in the Southern Hemisphere rotate in what direction?
- | | |
|----------------|----------------------|
| a. Clockwise | c. To the right |
| b. To the left | d. Counter-clockwise |

Matching

Write the letter of the ocean that best matches the description. Answers may be used more than once.

- | | |
|-------------|-------------|
| a. Artic | d. Pacific |
| b. Atlantic | e. Southern |
| c. Indian | |

- ___ 38. Abundant volcanic islands and Ring of Fire
- ___ 39. Touches the east coast of North America
- ___ 40. 3rd largest ocean
- ___ 41. Mariana Trench
- ___ 42. Covered with sea ice most of the year
- ___ 43. Holds the largest Mid-Ocean Ridge
- ___ 44. Begins at a latitude of 60 degrees S
- ___ 45. Holds the majority, 52%, of Earth's ocean water

Bonus - Answer on back of scantron. Use diagrams provided

46. Name the 5 oceans of the planet Earth (in order from smallest to largest)

47. Looking at the currents in the North Atlantic Gyre and starting with the N. Equatorial current.

List the type of water, **warm or cold**, as it moves through the gyre.

Do the same for the South Pacific Gyre, starting with the S. Equatorial.

48. If a spring tide occurred with a full moon, the next tide would be a neap tide and have a(n) _____ moon associated with it. In several days, there would be another spring tide with a _____ moon associated with it. Then by the end of the month, another neap tide would hit and the moon would be in a(n) _____.

49. Using the diagrams labelled 1-3, identify each diagram for one of the conditions for the ENSO (El Nino Southern Oscillation).

What type of weather pattern occurs in Texas during an El Nino and La Nina?

APPENDIX L
STUDENT ARTIFACTS

Oceans

What is a Hydrosphere?

- Combined mass of water found on, under, & above the surface of a planet or natural satellite
- Divided into 4 areas
 - Saltwater: oceans
 - freshwater: above & below
 - Ice (Cryosphere): ice caps & glaciers
 - Water Vapor: Atmosphere

Ocean or Sea?

- often used interchangeably, but difference
- based on geography
 - Oceans: vast bodies of water
 - Seas: smaller, located where land & ocean meet & partially enclosed by land

Why Study the Ocean?

- One of last frontiers on Earth
- Biological/Mineral resources
- Food shortages on land
- Influences weather & climate
- Travel

Oceanography: Science of our oceans that mixes biology, geology, chemistry & physics to unravel mysteries of the sea

- Physical Oceanography
- Geological Oceanography
- Chemical Oceanography
- Biological Oceanography

The Global Ocean

- covers 71% of Earth's surface
- Salt water
- 97% of water on Earth

Hemispheres of the Earth

Divisions of the Global Oceans

- Indian
- Pacific
- Atlantic
- Arctic
- Southern

Distinguishing Characteristics of Oceans

- Size, currents, water masses, seafloor features, land boundaries

Pacific Ocean: largest & deepest; 52% of Earth's water; 33% of surface

Avg depth: 2.7 miles / 4.3 km

Atlantic: 2nd largest; 26% ocean water; Avg depth 2.4 miles / 3.9 km

Indian: 3rd largest; 20% ocean water; Avg depth 2.4 miles / 3.9 km

Arctic: 4.2% ocean water; Surrounds North Pole; Smallest & shallowest

Southern (Antarctic): Newest; defined in 2000; starts @ 60°S latitude

Surrounds Antarctica; 6.1% ocean water

Why do Oceans appear blue?

- Due to how light is absorbed
- long wavelengths (red, yellow, orange) absorbed near surface
- short wavelengths (blues & greens) absorbed @ deeper depths

Light in the Ocean

- Photic Zone: Sunlit layer of water

- deepest in tropics
- Typical value: 100 meters
- Photosynthesis occurs here
- Most ocean life found here

- Aphotic Zone: Complete darkness

3/19/19

Hydrosphere

- saltwater
- freshwater
- ice cosmosphere

Ocean - vast bodies of water

Sea - smaller - land & ocean meet

Oceanography - study of ocean

Pacific - ring of fire

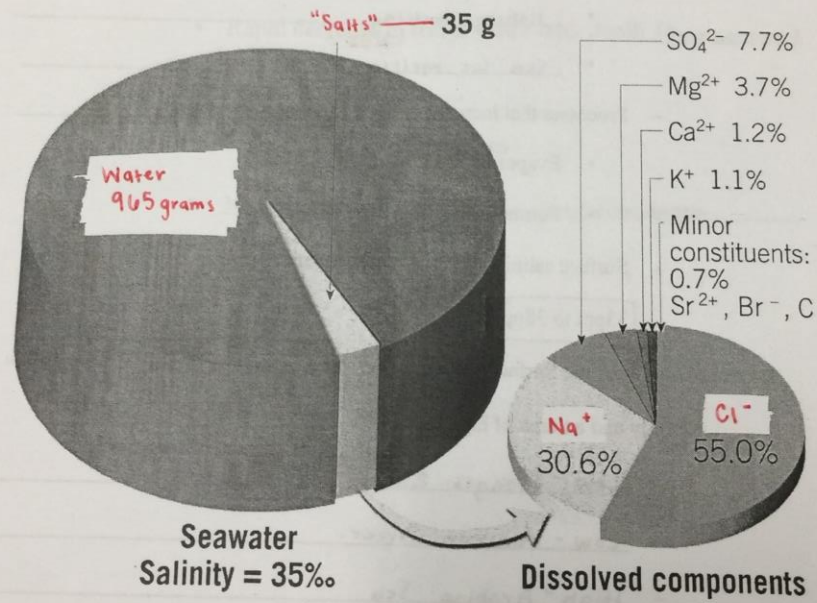
Photic zone - sunlight layer of water

Aphotic zone - complete darkness

Seawater Notes

Composition of Seawater

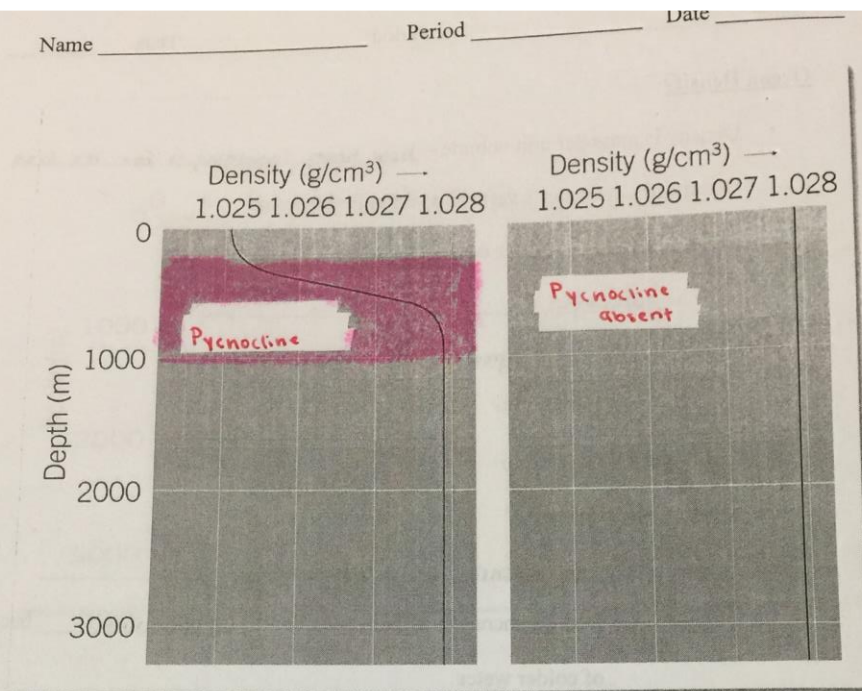
- Seawater consists of about 3.5 % (by weight) dissolved minerals
- Salinity
 - Total amount of Solid material dissolved in water
 - Typically expressed in parts-per-thousand (‰) or ppt
 - Average salinity is 35 ‰
 - Major constituent is Sodium Chloride (NaCl)
- Dissolved Components of Seawater – these are in the form of ions.



27

Name _____ Period _____ Date _____

- Sources of sea salts
 - Chemical weathering of rocks
 - Outgassing - gases from volcanic eruptions
(Sulfars & Nitrogens)
- Processes affecting seawater salinity
 - Variations in salinity are a consequence of changes in
Water content of the solution
- Processes affecting seawater salinity
 - Processes that decrease salinity (add water)
 - Precipitation
 - Runoff from land
 - Icebergs melting
 - Sea ice melting
 - Processes that increase salinity (remove water)
 - Evaporation
 - Formation of sea ice
 - Surface salinity in the open ocean ranges from
33ppt to 38ppt
- Looking at the Surface Salinity of our oceans, we can identify 2 areas of low salinity and an area of high salinity
 - Low - Ganges River
 - Low - Amazon River
 - High - Arabian Sea



- Ocean layering

- Layered according to density
- Three-layered structure

- Surface mixed zone *majority sea life in area ; photosynthesis*

- Sun warmed zone
- Zone of mixing
- Shallow (300 meters)

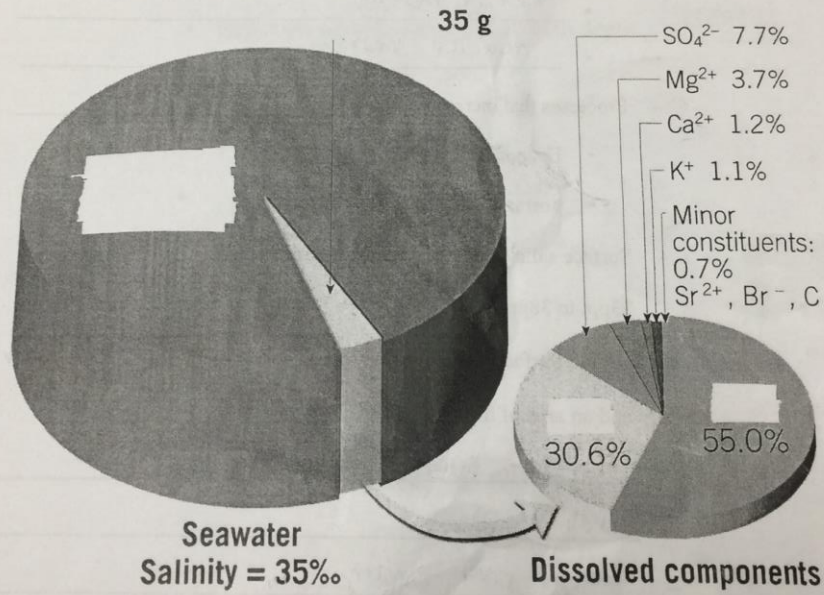
- Transition zone

- Between surface layer and deep zone
- Thermocline ; Pycnocline

Seawater Notes

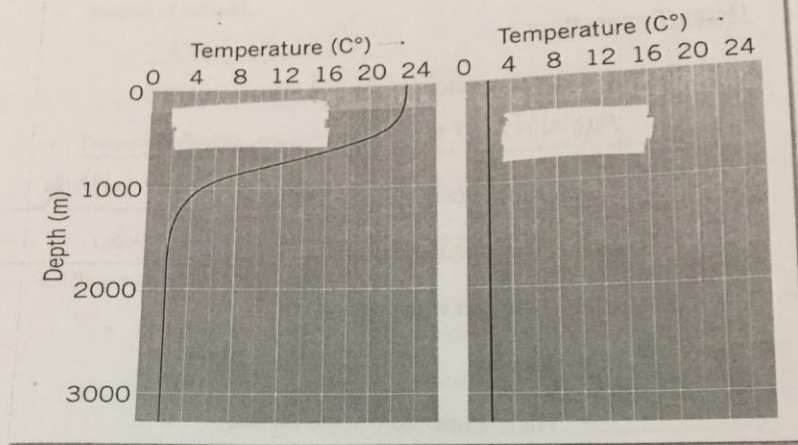
Composition of Seawater

- Seawater consists of about 3.5% dissolved minerals
- Salinity
 - Total amount of solid material dissolved in water
 - Typically expressed in parts per thousand or ppt
 - Average salinity is 35‰
 - Major constituent is sodium chloride
- Dissolved Components of Seawater – these are in the form of ions.



2-1

Name _____ Period _____



- Ocean temperature over time
 - The unique thermal properties of seawater make it resistant to temperature changes
 - Global warming could eventually influence ocean temperatures

- Variations in surface temperature and salinity with latitude. List the temperature and salinity at the following latitudes.
 - 60°N _____
 - 20-30°N & S _____
 - 60°S _____
 - 0° _____

4/11/19
2-P

Oceans : Circulation & tides

Circulation types

- Atmospheric Circulation : depends on density
- Surface Ocean Circulation : depends on wind
- Deep Ocean Circulation : depends on density

? What are the other names given to deep ocean circulation?

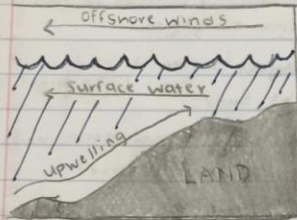
- Global Ocean Conveyor Belt & Thermohaline Circulation

? Why is Ocean Circulation important?

- transports heat from equators to poles / transport ^{organisms/nutrients} / Influences weather/climate

? What is upwelling?

- force that vertically moves cooler, nutrient rich waters from 1000 ft below surface to near surface



Deep Ocean Currents (Thermohaline)

2 Factors important in creating a dense mass of moving water:

1. Temperature
2. Salinity

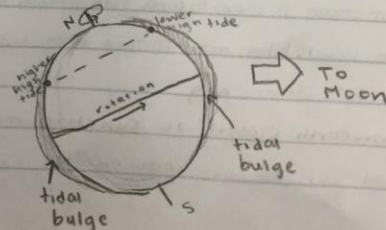
- Colder & Salty water is denser than warmer less salty water

Tides

Tides

- changes in elevation of ocean's surface
- caused by the gravitational forces exerted on earth by:
 - ↳ moon & lesser extent Sun

• Idealized Tidal Bulges on Earth



Ocean Currents

Ocean Surface Circulation

- ocean currents are masses of water that flow from one place to another
- Surface currents develop from friction between ocean & wind that blows across surface
- huge, slowly moving gyres
- 5 main gyres:
 - North Pacific, South Pacific, North Atlantic, South Atlantic, Indian
- related to atmospheric circulation
- deflected by Coriolis effect:
 - to the right in N. Hemisphere
 - to left in S. Hemisphere
- four main currents generally exist within each gyre
- Importance of Surface Currents:
 - Climate
 - currents from low latitudes into high latitudes (warm currents)
 - transfer heat from warm to cooler areas
 - influence of cold currents is most pronounced in the tropics or during the summer months in middle latitudes

3-B

Circulation (types)

- Atmospheric Circulation
 - Depends on density
- Surface ocean circulation
 - Depends on the wind
- Deep ocean circulation
 - Depends on density

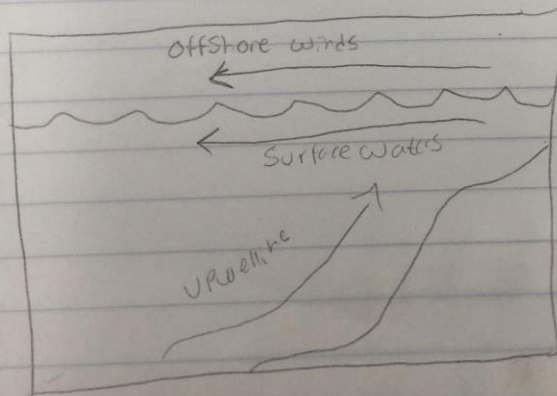
- * What are the other names given to Deep Ocean Circulation?
 - Thermohaline
 - Ocean Convection
 - Halo-temperature
 - Halo-salt, same

Why is Ocean Circulation Important?

- A • Transports heat from equator to Poles
- Transports nutrients & organisms
- Influences weather & climate

What is upwelling?

The force that vertically moves cooler, nutrient rich water from approximately 1000 feet below the surface to the near surface.



Incomplete

9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

Circulation Notes

3-P

4/11

types:

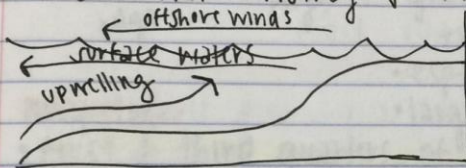
- atmosphere circulation (density)
- surface ocean circulation (wind)
- deep ocean circulation (density)

* other names given to deep ocean circulation?
- ocean conveyor belt & thermohaline

* why is it important?
- transports heat; nutrients & organisms; influences climate

• what is upwelling?

- cold water rising & mixes w/ warm water

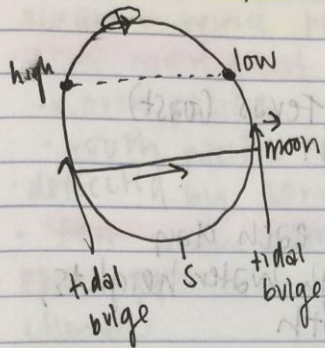


deep ocean currents: temp & salinity = denseness

4/12

Tides notes

- changes in elevation of the ocean surface
- caused by the gravitational forces exerted upon Earth by the moon & earth



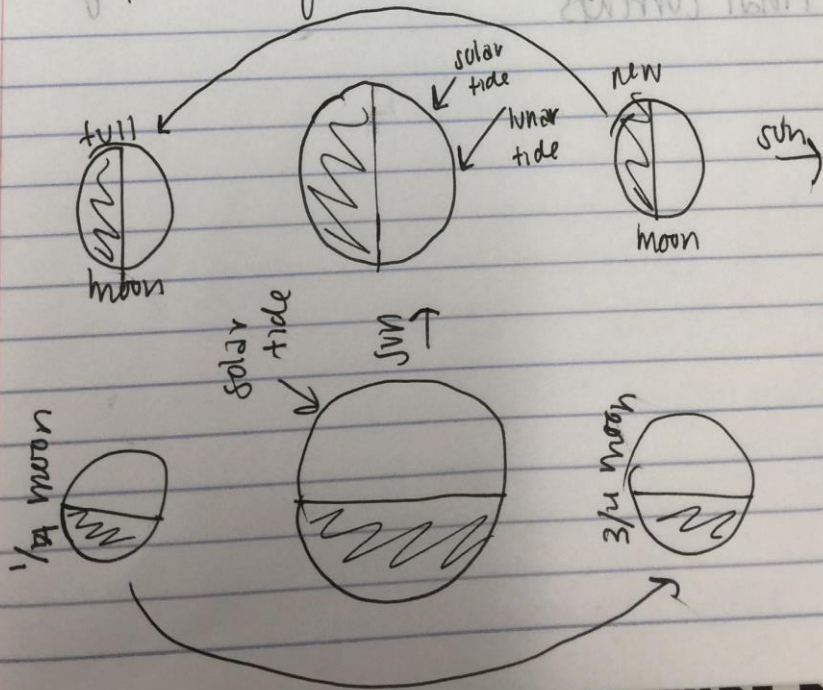
idealized tidal bulges on earth

Spring tide:

- new & full moons
- gravitational forces added together
- especially high & low tides

neap tide:

- first & third quarters of the moon
- gravitational forces are offset
- daily tidal range is least



WIDE RULED

APPENDIX M
TEACHER JOURNAL TEMPLATE

Teacher Journal Template

Action Research Teacher Journal		Date:	
Students Absent: 1 st period 2 nd Period 3 rd Period 4 th Period			
Data Collection (instrument) used:		Planning Log: description/ time spent preparing	
What went well in class?		Classroom climate and engagement observations:	
1 st Period			
2 nd Period			
3 rd Period			
4 th Period			
What didn't go well? What to think about or do differently:			