THE IMPACT OF PRIOR KNOWLEDGE ON STUDENTS’ NOTETAKING,
LEARNING, AND JUDGMENTS OF LEARNING

by

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The Impact of Prior Knowledge on Students’ Notetaking, Learning, and Judgments of Learning

Research on student learning is important and has advanced knowledge of best learning practices for both students and educators. These advances in knowledge help students identify challenges in their learning and develop strategies to overcome those challenges, as well as help educators employ evidence-based learning strategies into their teaching practices to foster student learning. One strategy that students often employ is notetaking during classes. Thus, it is critical to explore factors that impact student notetaking. Moreover, ample evidence indicates that notetaking positively impacts students’ learning (Kiewra, 1985; Kiewra, 1989; Kiewra, DuBois, Christian, McShane, Meyerhoffer, & Roskelley, 1991). Even so, researchers have not yet explored how students’ knowledge about a topic before attending a lecture impacts their notetaking. Many educators advise their students to read assigned readings prior to attending lecture even though there is no empirical evidence that doing so improves the quality of their notes. Thus, the goal of the current work is to examine this novel issue. The secondary goals of this work are to assess how students’ prior knowledge impacts their judgements about their learning, as well as their actual learning. I will first discuss how students regulate their learning by taking notes. Then, I will discuss theoretical explanations for why notetaking benefits students’ learning. Finally, I will discuss factors that may impact students’ notes and why these factors are important to consider for the current work.

Students’ Self-Regulated Learning

Research on student learning is a large field. Most of the work examining how students regulate their learning involves students selecting study strategies to implement. For example, a student studying terms and definitions for an exam on Earth’s oceans and atmospheres must
students decide what information is important to study, how to study, how long to study, and when to terminate study. As such, self-regulated learning includes multiple processes, such as goal setting, assessing learning progress, anticipating performance in the future, and selecting strategies (Bjork, Dunlosky, & Kornell, 2013; Zimmerman, 1990).

Two key processes in self-regulated learning are monitoring and control (Nelson & Narens, 1990). Students monitor their learning by making assessments about their own knowledge on a topic (i.e., *How well do I know the terms for the exam?*), and these assessments influence which strategies students employ to learn material (i.e., *I need to continue studying the Coriolis effect*). Students control their learning by changing their study behaviors based upon their monitoring (Zimmerman, 1990). These behaviors, in turn, inform future assessments of knowledge (Bjork et al., 2013). Importantly, these two processes actively work together to help students regulate their learning, and they can impact students’ actual learning (Thiede, 1999; Thiede, Anderson, & Therriault, 2003).

Students self-regulate their learning in classrooms by taking notes and deciding what is important to record. Students decide how much information to record in notes (the *quantity* of information in notes) and the type of content to record in notes (the *quality* of information in notes). These two operationalizations for notes are important because both will be considered in the present work. Even so, most researchers have focused on students’ note quality rather than quantity, so henceforth, the term “notes” to refer to the quality of notes. Importantly, most students report taking notes in classrooms. For example, 91% of undergraduate science students report taking notes (Bonner & Holliday, 2006). Another study examining notetaking behavior of undergraduate students found that all students interviewed reported taking notes (Van Meter, Yokoi, & Pressley, 1994). Given that most students report taking notes for their classes (Bonner
& Holliday, 2006; Van Meter et al., 1994), it is important to consider how taking notes impacts students’ learning.

Empirical Evidence and Theoretical Perspectives on Notetaking

In a foundational study, Di Vesta and Gray (1972) had participants listen to three 5-min passages, each containing three phases: a listening phase, a rehearsal phase, and a testing phase. The listening phase is of most interest because participants’ notetaking was manipulated during it. During the listening phase, half of the participants recorded notes while listening to the lecture and half did not. After listening to each of the passages, all participants took a free-recall test and a multiple-choice test. Importantly, participants who took notes recalled more ideas on the free-recall test than did those who did not take notes. Additionally, they had higher multiple-choice test scores than did participants who did not take notes. Overall, these findings suggest that notetaking, compared to not taking notes, is beneficial for students’ learning (Annis & Davis, 1975; Di Vesta & Gray, 1973; Fisher & Harris, 1973; Kiewra, 1985; Rickards & Friedman, 1978; Shrager & Mayer, 1989).

There are two primary theoretical explanations to account for learning gains following notetaking (relative to not taking notes). One explanation is that notetaking serves an external-storage function, in which notetaking provides a stored copy of information from a lecture (Kiewra, 1987). Based upon this external-storage perspective, enhanced learning following notetaking is due to reviewing notes prior to a final test. Students who take notes during learning have a stored source of information to review for a future test. However, students who do not take notes during learning do not have a stored source of information to review. Thus, between study and test, students who do not take notes do not have this resource to boost their learning. To illustrate, Fisher and Harris (1973) had participants watch a 40-min lecture, and participants
were separated into one of five groups. Participants took no notes and reviewed the lecturer’s notes, took no notes and mentally reviewed information in the lecture, took notes and mentally reviewed information in the lecture, took notes and reviewed their own notes, or took notes and reviewed the lecturer’s notes. Participants who took and reviewed notes had better memory performance than did participants who did not take notes, replicating the findings from Di Vesta et al. (1972). As important, participants who only reviewed notes without taking them had better memory performance than did participants who did not take notes. Thus, reviewing notes is important for learning from lectures. Indeed, much evidence has been found in support of the external-storage perspective of notetaking, with many researchers finding a boost in memory performance when notes taken during a lecture are reviewed compared to when notes taken during a lecture are not reviewed (Annis et al., 1975; Kiewra et al., 1991; Kiewra, DuBois, Christiansen, Sung-II, & Lindberg, 1989).

Another explanation is that notetaking serves an encoding function. According to the encoding perspective, the process of taking notes directly facilitates learning during acquisition. During notetaking, students must not only process the information as they are listening to it, but they must also record it into their notes. As such, this additional processing may facilitate superior encoding of information. To illustrate, Di Vesta and Gray (1973) had participants listen to a series of tapes on fire ants in the United States. Participants were instructed to either take notes or not. The order that participants listened to the tapes was also manipulated; however, this manipulation is not germane to the encoding function of notetaking and will not be discussed further. After listening to the tapes, participants took a free-recall and a true-false test. Participants who took notes performed better on both tests than did participants who did not take notes. Critically, participants were not allowed to review their notes prior to the tests, so learning
gains were due strictly to the process of taking notes (see also Annis et al., 1975; Di Vesta et al., 1972; Kiewra, 1989; Kiewra & Benton, 1988; Rickards et al., 1978).

The external-storage and encoding perspectives are not mutually exclusive and both mechanisms may simultaneously impact learning. However, the encoding mechanism is my primary interest and focus for the present work in part because there is less work focused on it. Importantly, there are many factors during notetaking that may impact students’ encoding and subsequent learning of information. This could have critical consequences for students including having poorer quality notes and potentially reduced learning gains. Thus, the aim of the present work is to examine the encoding mechanism of notetaking, and specifically, how knowledge gained prior to notetaking may impact students’ notes.

**Why Does Notetaking Impact Encoding?**

Notetaking may benefit encoding via generative processing (Jonassen, 1984; Peper & Mayer, 1978; Peper & Mayer, 1986; Shrager & Mayer, 1989). According to the *generative hypothesis*, notetaking facilitates building relationships between previously learned information and newly presented information. This act of generating relationships between prior knowledge and newly presented information results in superior encoding relative to simply transcribing information or not taking notes at all. Consider, for example, research conducted by Peper and Mayer (1978). Participants listened to a 16-min lecture about a programming software. While they listened to the lecture, half of the participants took notes and half did not. Next, participants received a test with near-transfer problems and far-transfer problems. The near-transfer problems closely resembled how information was presented during the lecture, and the far-transfer problems required some amount of inference. Participants who took notes were better able to generate relationships between concepts and scored higher on far-transfer problems than did
students who did not take notes. Thus, participants who took notes showed evidence of
generative processing during notetaking. Importantly, note content was not assessed during this
study, leaving open the possibility that students with varying amounts of prior knowledge may
record different information in their notes.

**Factors That Impact Students’ Notetaking**

Although it has been established that notetaking can facilitate encoding via generative
processing, there are factors that may impact students’ notetaking. Many students experience
challenges with selecting the most important information for their notes, and the failure to attend
to and record important information can impact memory performance (Kiewra, 1987).
Additionally, the modality of notetaking may influence learning gains. Compared with typed
notes, in some cases hand-written notes are associated with greater quality of information at the
expense of quantity (Mueller & Oppenheimer, 2014; but see Bui, Myerson, & Hale, 2013).
Concerning lecturing, some factors, such as lecture rate, organization of materials, and cues to
important information can also impact students’ processing during notetaking (Jansen, Lakens, &

Prior knowledge is one factor that may particularly impact students’ encoding during
notetaking. In actual learning environments, students come to each class with unique levels of
knowledge about that content. For instance, in upper level classes, students may have been
exposed to some of the information in lower-level classes. As well, consider that professors often
recommend that student read assigned readings prior to coming to class. Relative to students who
do not read assigned readings prior to class, those who do will have more prior knowledge about
the content to-be-discussed.
Prior knowledge may impact notetaking in one of two ways. Prior knowledge of information may assist students with taking notes. According to the generative hypothesis of notetaking (i.e., notetaking facilitates building relationships between prior knowledge and newly presented information), the prior knowledge a student has will influence his/her ability to generate relationships between information. Without an adequate knowledge base, it can be difficult to generate relationships between previously presented ideas and newly presented information. Additionally, prior knowledge about a topic may benefit notetaking by alleviating information-processing demands (Kiewra et al., 1987; Kiewra et al., 1988). For example, a student who has prior knowledge about a presented topic during a lecture may already have sufficient knowledge to determine which information should and should not be recorded into notes. Thus, the student would be able to dedicate more resources to integrating information into their existing knowledge.

Alternatively, having prior knowledge about a topic may counterintuitively hinder notetaking by influencing students’ metacognitive experiences during learning. For example, a student with prior knowledge about a topic may use the subjective experience of familiarity with the information as an indicator that they know the material well. Feelings of familiarity can cause students to feel overconfident in their learning, and to be less likely to engage in beneficial learning strategies (Finn & Tauber, 2015). In turn, students with prior knowledge may disengage from notetaking due to feeling that the information is already known. Critically, the use of such subjective experiences as an indicator of learning can impact students’ judgements during learning (Kelley & Jacoby, 1996; Whittlesea, Jacoby, & Girard, 1990). As an example, Kelley and Jacoby (1996) had learners solve anagrams with the solution to the anagrams either present or absent. Afterward, participants rated how difficult the anagram would be for others to solve.
With the solution present, participants rated the anagrams as less difficult for others to solve than did participants who had the solution present. Thus, participants who had knowledge about the solutions to the anagrams were overconfident in how easily the anagram could be solved. Given this prior work and resulting predictions based on it, measuring students’ metacognitive experiences is a key secondary goal of the current work.

**The Present Experiments**

The first aim of Experiments 1 and 2 was to investigate how prior knowledge impacts the quality and quantity of students’ notes. Although students report that prior knowledge impacts their notetaking (Bonner & Holiday, 2006; Van Meter, Yokoi, & Pressley, 1994), no researchers have examined if prior knowledge impacts the content of students’ notes. Thus, the present experiments were the first to examine the impact of students’ prior knowledge on the content of students’ notes. To do so, half of the students read a text about a topic before watching a video lecture about it, and the other half of students did not.

There are competing hypotheses for how reading a text prior to taking notes may impact students’ notes. According to the generative hypothesis, students who read the text before the lecture should be better able to generate connections between previously learned information and newly presented information relative to students who did not read the text, resulting in higher quality and quantity notes. Alternatively, according to the metacognitive hypothesis, students who read the text before the lecture should have increased familiarity with the content and will be more likely to use this information as an index of their knowledge relative to students who did not read the text, resulting in poorer quality and quantity of notes.

To explore students’ subjective experiences, my second aim was to investigate the impact of prior knowledge on students’ judgments of learning (JOLs). After watching the video,
students gave a self-paced JOL on a scale of 0 to 100 indicating how they believed they would perform on a multiple-choice test over the material in the future. Based on metacognitive theory (Finn & Tauber, 2015; Kelley & Jacoby, 1996; Whittlesea et al., 1990), I predicted that students who read the text before watching the lecture would give higher JOLs than would students who did not read the text.

For completeness, the third aim of Experiments 1 and 2 was to investigate the impact of prior knowledge on actual learning. Repeated exposures to information typically improves memory for it relative to fewer exposures to information (Agarwal, Karpicke, Kang, Roediger, & McDermott, 2008; Koriat, 1997; Meeter & Nelson, 2003; Nelson, 1977). Thus, I predicted that students who read the text before the lecture would have outperform students who did not read the text on a memory test. In Experiments 1 and 2, I explored these predictions by testing students’ memory following a lecture.

The fourth and final aim of Experiments 1 and 2 was to investigate students’ self-reported classroom behavior and beliefs about notetaking and reading. Students’ beliefs about what benefits their learning are not always accurate (Karpicke, Butler, & Roediger, 2009); thus, they may have beliefs about how reading impacts their notetaking that is not supported by actual evidence. Concerning notetaking, there are many decisions students make when taking notes for a specific class, but students most often prefer to take notes by hand (Morehead, Dunlosky, Rawson, Blasiman, & Hollis, 2019; Witherby & Tauber, 2019). Even so, in the current experiments students took notes by typing to avoid challenges with reading and correctly interpreting their handwriting, which would contribute to transcription errors. To examine the possibility that notetaking modality may impact notetaking behavior, I measured participants’
preferred notetaking method. Participants also self-reported how often they read assigned readings prior to attending lecture and their beliefs about how reading impacts their notetaking.

Experiment 1

In Experiment 1, half of the participants read a short text on Earth’s oceans and atmospheres, and the other half of the participants did not read a text. Afterward, participants watched a 30-min lecture video on Earth’s oceans and atmospheres. During the video, participants were instructed to take notes on a laptop as they would if they were taking notes for a class in which they would be tested over the material. After watching the video, participants gave a JOL predicting how they would perform on a future test over the material. Finally, all participants took a multiple-choice test over the content in the lecture.

Method

Design and Participants

Text reading (read-before-lecture vs. no-reading) was a between-participants manipulation, and participants were randomly assigned to group. Due to a lack of research on this topic, I was unable to conduct a power analysis to estimate the number of participants. Using a conventional rule of thumb in cognitive research, a sample size of 80 participants (40 randomly assigned to group) was selected for the current experiment. One participant was dropped from analyses because the researcher did not allow them to take notes, and one participant was dropped from analyses because they did not take any notes. Thus, the final sample size was 78 (read-before-lecture group = 40, no-reading group = 38).

Materials and Procedure

Materials included a 30-min lecture video and a 4-page text document about Earth’s oceans and atmospheres (Rollins, 1990), and a 22-question multiple-choice test
on information from the video (see Appendix for materials). The video and all questions were displayed on a computer screen and were programmed using LiveCode version 8.1.6. Participants were seated at individual computers and were instructed that they would be learning about Earth’s oceans and atmospheres during the experiment.

Even though participants came from the psychology subject pool and were expected to have little knowledge about Earth’s oceans and atmospheres, it was important to consider what knowledge they may have had prior to the experiment. To address this, participants answered several questions to assess prior exposure to any experimental materials. First, participants were asked if they knew about two key terms discussed in the video. Specifically, participants were asked, *Can you define the Coriolis effect?* and *Can you define thermohaline circulation?* Participants were given the options yes and no. If participants selected yes in response to either question, a text box appeared on the screen and they were instructed to explain that respective term. Second, participants responded to the following prompt,

“Below is a list of courses offered at TCU. Please check all the courses that you have taken or are currently taking. If you have not taken any of these courses, please check the box next to “None” and click continue.”

Participants had the following options to choose from: Introduction to Marine Science, Concepts in Environmental Science, Weather and Climate, and None. These courses were selected because their course descriptions in the TCU course catalogue emphasize learning about topics related to the content participants learned. Last, participants received the following prompt,

“Below is a list of common topics in Earth Science. Please check all the topics that have been emphasized in a college course you have taken or are currently taking. If you have not taken a course that has emphasized any of these topics, please check the box next to “none” and click continue.”
Participants had the following options to choose from: Marine Science, Environmental Science, Meteorology, Oceanology, and None. These topics were chosen because they most closely fit the content participants learned.

After answering both prior knowledge questions, participants in the read-before-lecture group were provided the 4-page text document (adapted from Rollins, 1990). Because individuals have different preferences for reading (e.g., on a computer screen or on paper), participants chose to read the text on the computer screen or on paper. Identical information and images were in both modes of display. The text document contained key information covered in the video (see Appendix). However, it was not identical to the lecture, which reflects participants’ experiences reading actual textbook chapters prior to attending lectures. The text document contained 61 statements out of 213 total that overlapped with the lecture video. All information in the text was stated in the lecture video.

Participants in the read-before-lecture group were instructed to read the text carefully because they would be tested over the information in the future. Participants’ reading time was entirely self-paced, and they read out loud to ensure that they read the entire text. Text readings were audio recorded, and a trained researchers listened to them to ensure that participants adhered to directions. Participants in the no-reading group were not given a text to read prior to watching the lecture. Instead, they began watching the lecture video immediately following instructions.

To take notes, participants were given a laptop opened to a blank Word document. All participants were instructed to take notes while they watched the lecture video as they would in an actual classroom. Additionally, participants were reminded that they would have a test in the future over the content in the lecture video. Participants began watching the video after they
received all instructions. Following completion of the video, participants gave a self-paced JOL by responding to the following prompt, *How well do you think you will do a multiple-choice test over the information from the video?* Participants typed their JOL on a scale of 0 (*I will not answer any questions correctly*) to 100 (*I will answer all questions correctly*) in a text box located at the bottom of the screen. Immediately following the JOL, participants began the 22-question multiple-choice test, which was self-paced. Eleven of the test questions came from main idea statements in the lecture, 10 came from supporting detail statements, and 1 came from both a supporting detail and main idea statement. There were 15 questions that overlapped between the text and the lecture and 7 questions that only came from the lecture. A pilot study was conducted to ensure that participants were able to answer test questions without memory performance on the floor or ceiling. The pilot study included 42 participants drawn from the same subject pool as for the current experiments. Participants watched the entire video and took the multiple-choice test immediately after it (without taking notes). Item analyses were conducted to examine the mean overall performance on the test and mean performance on each test question. The mean performance on the multiple-choice test was 61.4% (*SE* = 0.03). Adjustments were made to three test questions that were either on the ceiling or on the floor. Specifically, questions 2 and 6 were adjusted to be more challenging because the average percentages correct were 100% and 92.5%, respectively. Question 22 was adjusted to improve clarity, and the average percent correct was 32.5%. The updated version of the test was used in the current experiments (see Appendix).

To measure participants’ classroom behaviors and beliefs regarding notetaking and reading prior to lecture, they responded to three questions following the multiple-choice test. The first question was, *During lectures, how do you usually prefer to take notes?* Participants were
given the options, By hand, By typing, It depends, and I don’t take notes. The second question was, How often do you read assigned reading prior to attending class lectures? The options given were, Always, Sometimes, and Never. The third question was, How do you think reading prior to attending class lectures impacts your notetaking? The options were, I think it helps my notetaking, I think it hurts my notetaking, and I don’t think it impacts my notetaking. If participants selected either of the first two options, a text box appeared on the screen with a prompt to explain why the selected that option. If participants indicated that they never read assigned reading prior to attending class lectures, they did not answer the third question. After answering the questions, participants were thanked for their participation and debriefed.

**Note Scoring**

A rubric was created that identified the main idea units in the lecture. To do so, three raters watched the lecture video and categorized each statement as a main idea, supporting detail, example, or unimportant detail. When all three raters disagreed on how a statement should be categorized, it was dropped from all analyses. Out of the total 213 idea units in the lecture, 28 were main ideas (13%), 77 were supporting details (36%), 37 idea units were examples (17%), 55 were unimportant details (26%), and 16 were dropped from all analyses (8%).

Each participant’s notes were separated into individual statements for scoring. Two raters blind to group assignment scored notes based upon the quality of the information. Raters scored statements by assigning 0.25, 0.5, 0.75, or 1 to each, and the scores from the two raters were averaged to create a single composite quality score for each participant. Thus, the quality of participants’ notes was determined based upon the mean proportion of main ideas in notes.
Results

The primary outcomes of interest were note quality and quantity. As well, I was interested in participants’ JOLs, memory performance, and self-reported notetaking preferences and beliefs about reading prior to attending lecture. Although not a primary interest, participants’ responses to prior knowledge questions are reported for completeness. Prior knowledge outcomes are reported first to establish the nature of the sample.

Adherence with Instructions

Overall, participants spent on average 7 min and 43 s reading the text, and all participants read the entire text. With the exception of two participants who were dropped from analyses, all participants took notes while watching the lecture.

Knowledge Prior to Experiment

I first evaluated knowledge about Earth’s oceans and atmospheres prior to exposure to any experimental materials. Only 1 participant (who was in the no-reading group) indicated that they knew information about the Coriolis effect. Even so, the participant did not correctly define Coriolis effect and did not demonstrate knowledge of the concept, so his/her data were retained in all analyses. There was no significant difference between the two groups in their knowledge of Coriolis effect, $\chi^2 (1) = 1.04, p = 0.311$. No participants reported any knowledge about thermohaline circulation. Thus, a chi-square test could not be conducted for this measure.

Next, I assessed participants’ responses to have taken classes offered at TCU with an emphasis in the experimental material. Two participants indicated that they had taken Concepts in Environmental Science (1 in the read-before-lecture group and 1 in the no-reading group), and 1 participant (who was in the read-before-lecture group) indicated that s/he had taken Weather and Climate. No participants reported taking or having taken Marine Science. Based on a chi-
square test, there was no significant difference between the two groups in the classes they had taken at TCU, $\chi^2 (1) = 0.32, p = 0.571$. All participants were retained in our analyses because the rates were low and did not differ between groups.

Lastly, I assessed participants’ responses to have taken any course that emphasized topics discussed in the experimental materials. Fifteen participants (5 in the read-before-lecture group and 10 in the no-reading group) had taken a course that emphasized Environmental Science, and 1 participant (who was in the no-reading group) had taken courses that emphasized Marine Science, Environmental Science, and Meteorology. No participant had taken a course that had an emphasis in Oceanology. Based on a chi-square test, there was no significant difference between the two groups in the number of courses they had taken with an emphasis in Marine Science, Environmental Science, and Meteorology, $\chi^2 (1) = 3.02, p = 0.082$. Three additional chi-square analyses were performed to evaluate whether there were group differences in each type of course taken (Marine Science, Environmental Science, or Meteorology). There were no significant differences between the two groups in the number of participants who had taken each type of course, $\chi^2 (1) \leq 3.02, ps \geq 0.082$. Most important, all analyses were conducted excluding the 16 participants who reported having taken courses that emphasized topics discussed in the experimental materials, and all the conclusions maintained. Thus, data from all participants ($N = 78$) were retained in the analyses reported below.

Note Quality

Note quality was assessed by comparing the mean proportion of main ideas in participants’ notes in the read-before-lecture and no-reading groups. Interrater reliability was assessed by performing a Pearson’s $r$ calculation, and reliability between the raters was high, $r = 0.94, p < 0.001$. These data were analyzed with an independent-samples $t$-test with the mean
proportion of main ideas as the dependent variable. In contrast to my predictions, there was no significant difference in the proportion of main ideas between the two groups, $t(76) = 0.03, p = 0.976, d = 0.14$ (see Figure 1).

![Figure 1. Mean proportion of main ideas in participants’ notes in Experiment 1. There were 29 total main idea units possible that participants could have included in their notes, and the ones included in their notes were scored for correctness. Error bars reflect the standard error of the means.](image)

**Note Quantity**

The quantity of participants’ notes was determined based upon the number of words participants wrote in their notes. The average number of words in participants’ notes was 305 ($SE = 32.00$). Using an independent-samples $t$-test, there was no significant difference in the mean number of words written by participants in the read-before-lecture and no-reading groups, $t(76) = 0.40, p = 0.550, d = 0.14$ (see Figure 2).
Figure 2. Mean number of words written in participants’ notes. Error bars reflect the standard error of the means.

**Magnitude of JOLs**

Participants’ JOLs were assessed using an independent-samples $t$-test, with mean JOLs in the read-before-lecture and no reading-groups as the dependent variable. Contrary to expectations, JOLs did not significantly differ for participants in the read-before-group relative to the no-reading group, $t(76) = 0.85, p = 0.397, d = 0.19$ (see Figure 3).

Figure 3. Mean judgments of learning for Experiment 1. Error bars reflect the standard error of the means.
Memory Performance

Most participants performed fairly well on the final test, and the mean percent correct on the test was 69% ($SE = 2.27$). Memory performance was assessed by comparing the mean percent correct on the multiple-choice test between the read-before-lecture and no-reading groups. Counter to my prediction, an independent-samples $t$-test revealed no significant difference in test performance between the read-before-lecture and no-reading groups, $t(76) = 1.38, p = 0.173, d = 0.31$ (see Figure 4).

Classroom Behavior and Beliefs

Overall, 41% of participants reported preferring to take notes by hand, 32% reported preferring to type, 26% reported that their preference depended on other factors, and 1% reported
that s/he doesn’t take notes (see Table 1). There was no significant difference between the two groups in preferred notetaking method, $\chi^2(1) \leq 3.03, ps \geq 0.082$.

Most participants reported only sometimes reading assigned readings prior to class (see Table 1). Specifically, 19% of participants reported that they always read assigned readings prior to lecture, 68% reported that they sometimes read assigned readings prior to lecture, and 13% reported that they never read assigned readings prior to lecture. Results from a chi-square test revealed that more participants in the no-reading group reported always reading assigned readings prior to lecture than did participants in the read-before-lecture group, $\chi^2(1) = 4.26, p = 0.039$. There was no significant difference between the two groups in the reported rates of sometimes and never reading assigned reading prior to lecture, $\chi^2(1) \leq 1.65, ps \geq 0.198$.

Although very few participants reported always reading assigned readings prior to lecture, an overwhelming majority of them believed that reading prior to lecture helps their notetaking during class (see Table 1). Out of the 69 participants who indicated that they read assigned readings either always or sometimes prior to lecture, 78% believed that reading prior to lecture helps their notetaking during class, 17% believed that reading prior to lecture doesn’t impact their notetaking, and 5% believed that reading prior to lecture hurts their notetaking. There was no significant difference between the two groups in their reported beliefs about how reading prior to lecture impacts their notetaking, $\chi^2(1) \leq 1.95, ps \geq 0.163$. For participants who indicated that reading helped their notetaking, they identified 4 main reasons for this belief. They already understand/know what to expect before class, class time is more useful/makes more sense, they take better/more concise notes, and they have enhanced learning from seeing material more than once. For participants who indicated that reading harmed their notetaking, 1 main reason was identified for this belief. They reported taking fewer notes.
Table 1.

*Reported Classroom Behavior and Beliefs for Experiment 1.*

<table>
<thead>
<tr>
<th>Group</th>
<th>Behavior or Belief</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preferred Notetaking Method</td>
</tr>
<tr>
<td></td>
<td>By Hand</td>
</tr>
<tr>
<td>Read-Before-Lecture</td>
<td>20</td>
</tr>
<tr>
<td>No-Reading</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>(41%)</td>
</tr>
</tbody>
</table>

|                            | Read Assigned Readings                 |
|                            | Always | Sometimes | Never |
| Read-Before-Lecture        | 4      | 30         | 6     |
| No-Reading                 | 11     | 24         | 4     |
|                            | (19%)  | (68%)      | (13%) |

|                            | How Reading Impacts Notes              |
|                            | Helps | Hurts  | Does Nothing |
| Read-Before-Lecture        | 29    | 1      | 4             |
| No-Reading                 | 25    | 2      | 8             |
|                            | (78%) | (5%)   | (17%)         |

*Note.* Numbers reflect the number of participants who gave that response. Percentages in parentheses reflect the percent of the sample that gave that response.
Experiment 2

In Experiment 1, reading prior to watching a lecture did not impact students’ notes, JOLs, or memory performance. These findings do not support my hypotheses and suggest that reading prior to watching a lecture may not impact any of these measures. Experiment 1 was the first study to assess how reading prior to watching a lecture might impact these factors. Because Experiment 1 was novel, it is important to determine whether these effects replicate. Thus, my primary goal for Experiment 2 was to replicate the findings from Experiment 1. A second goal was to consider more carefully what participants read prior to viewing the lecture. To do so, a third group was included in Experiment 2 (unrelated-reading-before-lecture group) in which participants read an unrelated text before watching the lecture video. By including this group, task demands and time were equated before the lecture for the group that read a related text before watching the lecture (related-reading-before-lecture group) and the unrelated-reading-before-lecture group.

Method

Design and Participants

Text reading (related-reading-before-lecture, unrelated-reading-before-lecture, no-reading) was manipulated between-participants, and participants were randomly assigned to groups. I was unable to conduct a power analysis due to the lack of research in this area and the obtained null effects in Experiment 1. A sample size of 150 was determined by using a standard rule-of-thumb and adding an additional 10 participants per group to combat issues with statistical power. Data from 4 participants were dropped due to not taking notes during the lecture, and data from 1 participant were dropped because s/he had prior exposure to experimental materials. Data from these 5 participants were replaced by recruiting additional participants, and the final sample
size was 150 (related-reading-before-lecture group = 50, no-reading group = 52, unrelated-reading-before-lecture group = 48). All participants were from the same subject pool, and none of them participated in Experiment 1.

**Materials and Procedure**

The materials were nearly identical to those used in Experiment 1, with only one exception: an additional text that was unrelated to the lecture video was included in this experiment. This text was matched in length (4-pages) to the text document on Earth’s oceans and atmospheres. The content of this text covered basic principles in chemistry and steps towards a theory of everything (see Appendix for materials).

The procedure was nearly identical to the procedure in Experiment 1. Participants answered the same questions probing their prior exposure to any experimental materials. The related-reading-before-lecture group and the no-reading group were identical to those of Experiment 1. Specifically, the related-reading-before-lecture group read the 4-page related text document prior to watching the lecture video. Participants then took notes on a laptop while watching a 30-min lecture video about Earth’s oceans and atmospheres and gave a JOL immediately following the video. The no-reading group did not read a text before watching the lecture and simply watched the video and gave a JOL following the video. The unrelated-reading-before-lecture group was provided with a text document matched in length that was unrelated to the lecture video. This group received identical instructions as the related-reading-before-lecture group, and the rest of the procedures for this group was identical to the other two groups.
Results

As in Experiment 1, participants’ responses to prior knowledge questions will be discussed first, followed by the note quality, note quantity, JOLs, and memory performance.

Knowledge Prior to the Experiment

Participants’ prior exposure to experimental materials was assessed by comparing rates on the prior knowledge measures between the related-reading-before-lecture group, the unrelated-reading-before-lecture group, and the no-reading group. Similar to Experiment 1, very few participants indicated having knowledge about the Coriolis effect (2 participants – one in the related-reading-before-lecture group and one in the unrelated-reading-before-lecture group indicated knowledge of Coriolis effect). One of these participants gave a full and accurate description of Coriolis effect, and thus, their data were excluded from all analyses. The other participant did not give an accurate description of Coriolis effect, so his/her data were retained in all analyses. The three groups did not significantly differ in their knowledge of Coriolis effect, $\chi^2 (2) = 2.14, p = 0.343$. One participant (in the no-reading group) indicated having knowledge of thermohaline circulation. However, their data were retained in all analyses because the participant did not give a full or accurate description of it. There was no significant difference between the three groups in their prior knowledge of thermohaline circulation, $\chi^2 (2) = 1.90, p = 0.387$.

I also evaluated participants’ responses to courses taken at TCU. Four participants indicated that they had taken Concepts in Environmental Science (3 in the unrelated-reading-before-lecture group and 1 in the no-reading group). One participant (in the related-reading-before-lecture group) indicated that s/he had taken Weather and Climate, and no participants reported taking or having taken Marine Science. There was no significant difference between the
three groups in the classes they had taken at TCU, $\chi^2 (2) = 1.86, p = 0.394$. Thus, data from all participants were retained in analyses.

I assessed participants’ responses to taking or having taken any course with an emphasis in topics discussed in the experimental materials. Twenty-eight participants (13 in the unrelated-reading-before-lecture group, 8 in the no-reading group, and 7 in the related-reading-before-lecture group) had taken a course that emphasized Environmental Science, 1 participant (in the related-reading-before-lecture group) had taken a course that emphasized meteorology, and 3 participants (from the no-reading group) had taken courses that emphasized Marine Science and Environmental Science. None of the participants had taken a course with an emphasis in Oceanology. There was no significant difference between the three groups in the number of courses they had taken with an emphasis in Marine Science, Environmental Science, and Meteorology, $\chi^2 (2) = 1.79, p = 0.408$. Even so, three additional chi-square tests were conducted to examine potential group differences in each type of course taken. There were no significant differences between the three groups in the number of participants who had taken each course, $\chi^2 s (2) \leq 5.77, ps \geq 0.056$. Critically, all analyses were conducted excluding the 32 participants who reported having taken courses that emphasized topics discussed in the experimental materials, and all conclusions maintained. Thus, data from all these participants were retained in analyses reported below.

**Note Quality**

I assessed note quality by comparing the mean proportion of main ideas in participants’ notes in the related-reading-before-lecture group, no-reading group, and unrelated-reading-before-lecture group. Interrater reliability was evaluated by performing a Person’s $r$ calculation, and reliability was high, $r = 0.92, p < 0.001$. Based upon results from a one-way ANOVA, there
was no significant difference in the proportion of main ideas in notes between the three groups, $F(2, 149 = 0.01, p = 0.994$ (see Figure 5).

![Graph showing mean proportion of main ideas in notes](image)

**Figure 5.** Mean proportion of main ideas in participants’ notes in Experiment 2. There were 29 total main idea units possible that participants could have included in their notes, and the ones included in their notes were scored for correctness. Error bars reflect the standard error of the means.

**Note Quantity**

As in experiment 1, note quantity was determined based upon the number of words participants wrote in their notes. On average, participants wrote 365 words ($SE = 25.80$). A one-way ANOVA revealed that there was no significant difference in the mean number of words written by participants in the related-reading-before-lecture group, no-reading group, and unrelated-reading-before-lecture group, $F(2, 149) = 0.21, p = 0.811$ (see Figure 6).
Figure 6. Mean number of words written in participants’ notes for Experiment 2. Error bars reflect the standard error of the mean.

Magnitude of JOLs

JOLs were examined using a one-way ANOVA, with mean JOLs as the dependent variable. JOLs did not significantly differ based on group assignment, $F(2, 149) = 0.39, p = 0.678$ (see Figure 7).

Figure 7. Mean judgments of learning for Experiment 2. Error bars reflect the standard error of the mean.
Memory Performance

Similar to Experiment 1, participants performed well on the final test. The mean percent correct on the test was 72% ($SE = 1.07$). To assess memory performance, I compared the mean percent correct on the multiple-choice test between the three groups using a one-way ANOVA. Counter to my prediction, there was no significant difference in memory performance between the related-reading-before-lecture group, no-reading group, and unrelated-reading-before-lecture group, $F(2, 149) = 0.92, p = 0.402$ (see Figure 8).

![Figure 8. Test performance in Experiment 2. Error bars reflect the standard error of the mean.](image)

Classroom Behavior and Beliefs

I also assessed participants’ classroom behavior and beliefs about how reading before a lecture impacts their notetaking. Out of the 150 participants, 59% reported preferring to take notes by hand, 17% reported preferring to type notes, and 23% reported that their preference depended on other factors (see Table 2). All participants reported taking notes in their classes.
Based on results from chi-square tests, there was no significant difference between the three groups in preferred notetaking method, $\chi^2 s (2) \leq 2.50, ps \geq 0.287$.

Many participants reported reading assigned readings prior to lecture (see Table 2). Forty-two percent of participants reported that they always read assigned readings prior to lecture, 51% reported that they sometimes read assigned readings prior to lecture, and 7% of participants reported that they never read assigned readings prior to lecture. There were no significant differences between the three groups in reported reading of assigned readings, $\chi^2 s (2) \leq 1.72, ps \geq 0.422$.

Most participants believed that reading prior to lecture benefits their notetaking during class (see Table 2). Out of the 140 participants who indicated that they either sometimes or always read assigned readings, 84% believed that reading prior to attending lectures benefits their notetaking, and 16% believed that reading prior to attending lectures does not impact their notetaking. There were no participants that believed reading prior to lecture hurts their notetaking. A chi-square test was conducted to assess potential group differences in beliefs, and there was no significant difference between the three groups, $\chi^2 (2) = 0.15, p = 0.927$. For participants who believed that reading prior to lecture benefits their notetaking, they identified the same 4 reasons for this belief as did participants in Experiment 1. Namely, they already understand/know what to expect before class, class time is more useful/makes more sense, they take better/more concise notes, and they have enhanced learning from seeing material more than once.
Table 2.  
*Reported Classroom Behavior and Beliefs for Experiment 2.*

<table>
<thead>
<tr>
<th>Group</th>
<th>Behavior or Belief</th>
<th>Preferred Notetaking Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>By Hand</td>
</tr>
<tr>
<td>Related-Reading</td>
<td></td>
<td>33</td>
</tr>
<tr>
<td>No-Reading</td>
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<td>30</td>
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<tr>
<td>Unrelated-Reading</td>
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<td>26</td>
</tr>
<tr>
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<td>(59%)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Read Assigned Readings</th>
<th>Always</th>
<th>Sometimes</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related-Reading</td>
<td>23</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>No-Reading</td>
<td>20</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td>Unrelated-Reading</td>
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<td>23</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>(42%)</td>
<td>(51%)</td>
<td>(6%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How Reading Impacts Notes</th>
<th>Helps</th>
<th>Hurts</th>
<th>Does Nothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related-Reading</td>
<td>42</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>No-Reading</td>
<td>40</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Unrelated-Reading</td>
<td>36</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>(84%)</td>
<td>(0%)</td>
<td>(16%)</td>
</tr>
</tbody>
</table>

*Note.* Numbers reflect the number of participants who gave that response. Percentages in parentheses reflect the percent of the sample that gave that response.
General Discussion

Students who read a related text prior to watching a lecture video took notes similarly as did those who did not. This is counter to predictions based on theory in the notetaking and metacognitive literatures. Based upon theory in the notetaking literature, students who read a related text prior to watching a lecture video were expected to have higher quality notes (and to take more notes) relative to both students who did not read a text and students who read an unrelated text. This is because students who read a related text prior to watching a lecture had more prior knowledge about the content compared with all other students, which should have increased generative processing while taking notes (Jonassen, 1984; Peper & Mayer, 1978; Peper & Mayer, 1986; Shrager & Mayer, 1989). The alternative hypothesis, based upon the metacognitive literature, was that students who read a related text prior to watching a lecture video would take fewer notes, and they would be of poorer quality in comparison to all other students. This is due to reliance on familiarity with the information as diagnostic of learning (Finn & Tauber, 2015; Kelley & Jacoby, 1996; Whittlesea et al., 1990).

It is surprising that reading prior to a lecture did not impact students’ notes, and there are several reasons why this may have occurred. Students may not have actively attended to information in the text so those who read a related text prior to the lecture did not gain much content information from the reading. This is unlikely because students read the entire text aloud in front of a trained researcher. Additionally, a trained researcher listened to the students’ audio recordings to ensure each student followed instructions during the task. Another possibility is that students’ prior knowledge about the experimental material impacted their notetaking during the lecture video. That is, students’ prior knowledge about the content may have overshadowed any effects reading could have had on their notetaking. Contrary to this possibility, I conducted
analyses to ensure all conclusions maintained with students who had prior experience with the experimental material and all of the conclusions maintained. Thus, it is unlikely that students’ prior exposure about the experimental material impacted their notetaking in a meaningful way. I evaluated yet one more possibility in my research – namely, that students took a differing amount of notes depending on whether they read a related text or not, and these differences in quantity impacted note quality. In both experiments, there were no significant differences between groups in the amount of words in their notes, so note quality results are not bound by the number of words written.

It may be that the study materials are critical for detecting differences in notetaking between the groups of students who read (or not) prior to a lecture. Due to the lack of work examining how reading impacts notetaking during a lecture, I located and generated materials to use in the current set of experiments. An important part of generating materials was creating a rubric that classified each statement in the lecture into idea units. Even though there were three independent raters who watched the video and classified statements into idea units, there were still statements that could not be classified due to a lack of agreement between the three raters. This speaks to the difficult nature of working with these complex educational materials. The process of classifying statements into idea units can be subjective depending on how the rater views the importance of each. There is also a lack of work evaluating the content of students’ notes in this capacity, and there are many challenges with evaluating the content of students’ notes. Students vary in how they prefer to take notes (Morehead, Dunlosky, Rawson, Blasiman, & Hollis, 2019; Witherby & Tauber, 2019), and this poses challenges to examining the content in each students’ notes in a similar manner. It would be beneficial for researchers to explore how
the complexity of to-be-learned information impacts students’ notetaking, as well as explore the best ways to quantify the quality of students’ notes.

Another challenge related to the materials was creating a shorter version of the text document provided with the lecture video (Rollins, 1990). The text document closely overlapped with how information was presented during the lecture video. Thus, the overlap of the text and the lecture video paired with the short length of the text may have minimized the ability of students to engage in generative processing with the information. As well, it could have minimized students’ perceived familiarity with the materials. A potential next step for researchers is to examine how the length and the similarity of an assigned reading with a lecture impacts students’ actual learning and learning behaviors during a lecture. Another important next step is to further explore notetaking with complex educational materials that reflect what students are likely to encounter in actual classrooms. Although the materials used in the current research were complex and educationally-relevant, students most often have longer text readings and longer lectures over information presented in the text. Additional research using other complex materials may explain when reading is likely to impact students’ notetaking and memory performance. This has important implications for translating student learning research from the lab to actual classrooms.

Despite no impact of text reading on students’ notetaking, most students endorsed the belief that reading prior to attending a lecture helps their notetaking. There were several common themes for why students endorsed this belief, including beliefs that reading prior to attending class helps them take more concise notes, shapes their expectations for lecture, and aids in their understanding of material during lecture (cf. Witherby & Tauber, 2019). These findings add to a large body of literature demonstrating that students have beliefs about their learning that are
inconsistent with what actually impacts their learning, also called illusions of learning (Bjork et al., 2013). As one example, students often believe that studying one kind of item in a row many times (i.e., blocking) enhances learning relative to studying different kinds of items intermixed (i.e., interleaving), even though interleaving is typically better for learning (Kornell & Bjork, 2008; Tauber, Dunlosky, Rawson, Wahlheim, & Jacoby, 2013). As another example, students can also be susceptible to relying on the fluency of material, or the subjective ease with which the information is learned (Alter & Oppenheimer, 2009; Finn & Tauber, 2015; Kelly & Jacoby, 1996). One robust finding is that students who watch a lecture delivered by a fluent instructor (i.e., an instructor who speaks with confidence and uses prosody in their speech) give higher JOLs than do students who watch a lecture delivered by a disfluent instructor (i.e., an instructor who speaks in a monotone voice with lesser confidence). However, lecture fluency does not impact students’ actual learning (Carpenter, Mickes, Rahman, & Fernandez, 2016; Carpenter, Northern, Tauber, & Toftness, in press; Carpenter, Wilford, Kornell, & Mullaney, 2013; Toftness, Carpenter, Geller, Lauber, Johnson, & Armstrong, 2017).

Concerning students’ JOLs, there were no differences in the magnitude of JOLs between students who read a text compared to students who did not read a text or read an unrelated-text. I predicted that students who read a text prior to watching a lecture would give higher JOLs relative to all other students. Thus, I did not find the predicted effect. This is surprising, given previous findings that more familiarity with information typically elicits higher JOLs compared to less familiarity with information (Kelley & Jacoby, 1996). One reason why I may not have found this effect is because of the between-participant design of the experiments. Studies that examine how students use information as a basis for JOLs are often within-subject designs, and researchers suggest that within-subject designs are necessary to detect effects on metacognitive
judgments (Carroll & Nelson, 1993). For students to discriminate based upon a cue, they often need exposures to all levels of it. For example, in studies examining how the impact of concreteness (e.g., concrete: chair; abstract: peace) on JOLs, JOL effects are largest when students are exposed to both levels of the cue (Witherby & Tauber, 2017). Therefore, students may not have given higher JOLs in the read-before-lecture and the related-reading-before-lecture groups relative to the no-reading and unrelated-reading-before-lecture groups because they only had one experience (reading a related text or not reading a related text). A next step for researchers is to further explore how familiarity with complex educational information impacts students’ predictions. As one example, students take many courses throughout their educational career, and it is likely that they take courses that cover some similar content. Difficult, upper-level courses often build upon information discussed in comparatively easier, lower-level courses. Thus, students may feel as if they know the material well because they already have some experience with the material, even if they do not remember the material well. This can impact students’ judgments about the content, and students may make poor study choices.

Finally, memory performance was not affected by text reading prior to the lecture. This is counter to my prediction, which was that students who read a related text prior to watching a lecture would recall more relative to students who did not read or read an unrelated text prior to watching a lecture. This prediction was based upon evidence that multiple exposures to information typically enhances learning relative to fewer exposures to it (Agarwal et al., 2008; Koriat, 1997; Meeter & Nelson, 2003; Nelson, 1977). The null effect may be due to the materials used in the current set of experiments. The related-text was 4-pages long with images, whereas the lecture video was 30-minutes long. Thus, reading a related text prior to watching a lecture video may not have had a strong impact on memory performance because of the limited amount
of information presented in it relative to the larger amount of information presented in the lecture video. Although reading a text prior to a lecture does not hurt students’ learning, it may not have helped students’ learning in the current set of experiments because of the format of the text. Additional research is needed to explore how qualities of a text (e.g., length, overlap of information between content in the text and content in the lecture) may impact students’ learning during lectures. It is also possible that I did not observe an effect of reading prior to a lecture on memory performance because the test was too easy. Despite pilot data evaluating the quality of the test, students performed well on it in all experimental groups. Thus, the test may not have been a sensitive measure to detect an effect of reading on memory performance. Perhaps a different test format, such as a short-answer test, may be more sensitive to the effects of reading on memory performance because students are required to synthesize their knowledge about the material to answer test questions. A future direction for researchers is to examine how reading prior to lecture may impact memory performance on different types of tests.

In summary, reading prior to attending a lecture did not impact students’ notetaking during lectures, predictions of learning, or actual learning. There are several limitations to these findings though, including challenges with generating materials and scoring the quality of students’ notes. Researchers should continue to explore this to better understand how reading assigned readings may impact students’ learning and learning behaviors during lectures. An important finding was that students’ believed reading prior to a lecture impacts their notetaking during classrooms, which may be an illusion of learning. Further investigation into students’ notetaking processes is critical to fully understand how text reading impacts it (as well as predictions of learning and test performance).
References


Appendix

Related Text Document

Coriolis Force

◇ Coriolis is a perception that occurs as a consequence of us living on a planet that is rotating.

◇ The Earth is a rotating platform. When viewed from above the North Pole, it rotates counterclockwise. A plane flying uncorrected from New York to Los Angeles will therefore appear to bend to the right as a result of this rotation. This deflection is called Coriolis.

◇ The Southern Hemisphere also experiences Coriolis, but instead it moves things to the left.

◇ Any wind (which is a movement of air) or current (which is a movement of water) can be influenced by Coriolis.

The Wind

◇ The currents that most people are familiar with are called wind-driven, or surface, currents. That is, the act of the wind driving along the surface of the water pulls some of the water with it in a shearing interaction.

◇ Air moves from areas of high pressure to low pressure to equalize those 2 pressure zones. Differential pressure is caused by differential heating.

◇ Areas around the equator experience high amounts of radiation from the Sun. Thus, the air at the equator is warm, and because that warm air is less dense, it will rise and start to spread north and south of the equator.

◇ As the air starts to cool, it will sink and eventually cycle back to the equator, where it is heated up again. This is called a circulation cell.

◇ But we have yet to consider the impact of Coriolis in this In the Northern Hemisphere, the first circulation cell, located just north of the equator and extending to about 30° north, is called the Hadley cell, named after a British amateur meteorologist.
Return of air to the equator along the surface would be along the surface would be from the north to the south. However, Coriolis dictates that this movement would be deflected to its right. Therefore, the resultant wind moves diagonally from the northeast to the southwest. We associate the northern Hadley cell as having predictable, consistent northeasterly winds and call them the northeasterly trade winds.

The northern Hadley cell interacts with air to the north of it, causing a second circulation cell called the Ferrel cell, named after an American meteorologist. This second cell extends to about 60° north, and it interlocks with the lower-latitude Hadley cell. So, in this cell, air rises at around 60° north, travels at altitude south until it converges with the Hadley cell, sinks to the planet's surface, and then travels along the surface from south to north to complete the circulation loop.

But in the Northern Hemisphere, Coriolis force causes a deflection to the right, so instead we see winds traveling from the southwest-ish to the northeast-ish. Thus, the prevailing surface winds in the Ferrel cell are either westerlies or southwesterlies.

The final circulation cell, the Polar cell, is located from 60° north and upward. It's a much narrower cell, and to interlock with the Ferrel, it circulates in the same fashion as the Hadley cell, with winds moving from the pole south along the surface. Coriolis force deflects these to their right, causing easterly winds because that particular circulation cell is so narrow.

The cells that have been described for the Northern Hemisphere are mirrored in the Southern Hemisphere.
Surface water is dragged by these surface winds in directions that are more or less parallel to the wind. So, if we were to look at the North Atlantic basin, we can imagine a southwesterly wind traveling along the top northeastern edge and a northeasterly wind traveling along the bottom southwesterly edge. Those 2 winds pulling along water will eventually cause a circular current called a gyre that in that basin is clockwise.

Because these winds are predictable in both Southern and Northern Hemispheres at these different latitudes, we end up with 2 clockwise gyres in each of the North Atlantic and North Pacific Oceans and 3 counterclockwise gyres in the South Atlantic and South Pacific oceans, as well as the Indian Ocean.

The Thermohaline Current

Thermohaline currents happen deep underwater and regulate the heat balance of our planet.

Water has a high specific heat capacity, meaning that it can absorb heat without changing too much in temperature. And heating of Earth’s surface is uneven, with much more radiation received at the equator than at the poles. This heat is redistributed partly through air movement, but also through the movement of water cycling through the ocean’s depths.
In these kinds of currents, the poles are incredibly important. The North and South Poles are surrounded by water that is constantly being cooled. Cold water becomes dense and sinks, spreading out from high latitudes toward low latitudes. The water that has sunk has to be replaced with more water from the surface, which indirectly comes from low latitudes. A cycle is created, redistributing heat across the entire ocean.

The name of this process is thermohaline circulation. This circulatory system plays an unmatched role in regulating the planet’s climate.

If you are in hot areas, where there is more evaporation than there is precipitation, the water will increase in salinity and therefore become denser.

In areas where it is cold enough to freeze water, you can also create saltier water. This would cause the water immediately below the ice to become denser.

In both of these cases, that denser water will tend to sink, until a point that it reaches its neutral buoyancy—that is, a point when that water has the same mass as the water surrounding it for a given volume.

The density of seawater is variable. The 3 major factors that control density are temperature, salinity, and pressure.

The act of water sinking because of its increased density is a movement of water, and therefore a current. These currents are called thermohaline because the sinking is due changes in temperature (“thermo-”) and salinity (“-haline”).

We would refer to the parcel of water that is sinking as a water mass.

Water masses are huge, vast volumes of water that are constantly being generated at their source and sinking to their point of neutral buoyancy. They create circuits of moving cold water that is then replaced by warmer water. This is the essential idea behind the global ocean conveyor.

Water masses stack on top of each other according to their density. The interface between 2 water masses is called a front, and it represents a rapid change in density condition.
CHEMISTRY AS A BASIS FOR EVERYTHING

In the 18th and early 19th centuries, a legion of early chemists discovered that there were several fundamental substances they called elements that seemed to combine in different configurations. Chemistry occurred when the elements combined or broke apart.

Another key clue was revealed in the early 1800s, when English scientist John Dalton discovered that when elements combined, they combined in fixed ratios. Essentially, his work verified that atoms existed.

People had talked about atoms for more than 2000 years, but it took until the first years of the 19th century that we had experimental data that verified the idea. And with the discovery of atoms, our understanding of the behavior of matter had one of its first unification moments: All matter was made of atoms of elements.

Having this new unit of measure also made it possible to begin organizing even more observations. There were highly reactive elements and ones that were less reactive; some elements liked to interact with other elements more than others. And some mixed in a few ways—for example, carbon monoxide, which consists of a carbon and an oxygen atom, and carbon dioxide, which consists of a carbon and 2 oxygen atoms.
In 1869, many additional observations were brought together when Russian chemist Dmitri Mendeleev invented what is now called the periodic table of elements. He took the discrete pieces of knowledge developed by a century of chemists and alchemists and organized the elements in a big grid, in which each column contains atoms with similar chemical properties.

The periodic table is a pretty amazing achievement, but perhaps even more amazing is that when Mendeleev started to work out the table, he didn’t know about the more than 100 elements that are on the table today. He only knew about slightly more than 50, which means that he had some holes in his table, but he was able to work out the patterns with incomplete information.

When Mendeleev wrote it down, he didn’t know why the elements had the properties they do and why the patterns repeated. In fact, answering those questions would take another 50 years, when we finally understood the nature of the atom and the laws of quantum mechanics. All he knew at the time was that some elements reacted similarly and that the mass of these similar elements was different. But those 2 observations led him to his key insight.

There was a point in the 1880s when the best scientific minds in the world would look at the periodic table and wonder what those patterns were telling them. It would take the unifying ideas of nuclear and atomic physics to explain the mysteries of chemistry.
In many ways, that's where we are in our modern effort to develop a theory of everything. We know of patterns but don't know the underlying causes. And this, more than anything, is why we have such enthusiasm for the idea of unifying theories—because we've seen many examples of when patterns eventually turned into understanding.

Our modern understanding of atoms is that they have a particular structure, with a small and concentrated nucleus at the center surrounded by a cloud of electrons. The nucleus is made of protons and neutrons. With protons, neutrons, and electrons, we can build up all of the familiar kinds of matter.

The situation changed in 1964 and into the early 1970s, when physicists found that the protons and neutrons were made of even smaller particles, which are now called quarks.

The standard model is one of the 2 biggest steps toward a theory of everything. While nobody claims that we're done, we can regard the standard model as our current best guess of a grand unified theory. Whatever the final theory of everything looks like, the standard model will be part of it.

THE STANDARD MODEL

THE KNOWN FORCES

The 5 known forces are gravity, which keeps us firmly planted on the ground and guides the planets through the heavens; electromagnetism, which covers both electricity and magnetism, as well as light and chemistry; the strong nuclear force, which binds protons and neutrons together in the nucleus of atoms; the weak force, which is responsible for some forms of radioactivity; and the Higgs field, which gives mass to subatomic particles.
In the late 1960s, physicists showed that the weak force and electromagnetism were really 2 facets of a single thing, much in the same way that electricity and magnetism turned out to be 2 facets of what is now called electromagnetism.

Therefore, scientists often talk about an electroweak force. So, we might say that the forces are gravity, the electroweak force, the strong force, and the Higgs field. On the other hand, the Higgs field is inextricably tied up with the electroweak force, so maybe it can get tucked under the electroweak umbrella. Under that way of thinking, we have only 3 forces: gravity, the strong force, and the electroweak complex.

The strong force is the strongest of the known forces. It is incredibly strong over only very short ranges—such as the size of a proton. Once 2 particles are separated by a distance much larger than that, the strong force goes to zero.

The next strongest force is electromagnetism, which unifies electricity and magnetism into a single force. It’s much weaker than the strong force, but it has a different behavior as far as distance is concerned. Two particles experiencing the electromagnetic force will, in principle, feel a force between one another if they are located on opposite sides of the universe. That force will be very small, but it won’t be mathematically zero, because electromagnetism has infinite range.

The next weakest force is the weak force. The natural range of the weak force is about 1/1000 the size of a proton. However, at a separation of a femtometer, it is about 100,000 times weaker than the strong force. At its natural scale, the weak force is actually similar to electromagnetism, and that was the beautiful insight that allowed for electroweak unification.

Gravity has an infinite range like electromagnetism, but at the femtometer distance scale, gravity is approximately $10^{90}$ times weaker than the strong force. Gravity is extremely weak—so weak that we have never figured out a way to study it on these very small scales, so it is not covered by the standard model.

The Higgs field turns massless particles into massive ones.
Multiple-Choice Test

Option a. is the correct answer for each question. The questions were presented in a fixed-order with the options randomized anew for each participant.

1) When did our modern understanding of how the ocean works begin?
   a. A few hundred years ago, with the advent of great ocean explorers
   b. A few decades ago, with the advent of great ocean explorers
   c. A few hundred years ago, with the invention of technology created to assist with oceanography, including almanacs and sextants
   d. A few decades ago, with the invention of technology created to assist with oceanography, including almanacs and sextants

2) Who is the first ocean explorer credited with combining science with exploration during voyages?
   a. Captain James Cook
   b. Captain John Cabot
   c. Captain John Cook
   d. Captain Christopher Columbus

3) What is the Coriolis Force?
   a. A perception that occurs as a consequence of us living on a planet that is rotating
   b. A type of wind that forces main belts of wind to move in particular directions across the Earth
   c. A term used to describe how curve-balls occur when playing baseball
   d. A force that occurs as a consequence of global circulation

4) According to the Coriolis Force, the direction of the perceived curve of an object is a function of ___________.
   a. the direction of rotation
   b. the Earth’s gravitational pull
   c. movement of winds in the Northern and Southern hemispheres
   d. high-speed winds in the atmosphere colliding with local winds near the surface of the Earth

5) Because of the Coriolis Force, the Southern Hemisphere deflects to the _______, and the Northern Hemisphere deflects to the _______.
   a. Left; right
   b. Right; left
   c. North; south
   d. South; north

6) Coriolis Force can impact ___________.
   a. Both wind and currents
   b. Wind
c. Currents
d. Neither wind nor currents

7) What two factors does the lecturer say can cause a current?
a. Wind and thermohaline circulation
b. Wind and surface currents
c. Thermohaline circulation and heat from the Equator
d. Thermohaline circulation and surface currents

8) How does the amount of radiation from the sun impact circulation cells?
a. High amounts of radiation from the sun cause the air to spread, while low amounts of radiation cause the air to cycle back to where it was heated
b. Low amounts of radiation from the sun cause the air to spread, while high amounts of radiation cause the air to cycle back to where it was heated
c. High amounts of radiation from the sun cause the air to move in spontaneous and unpredictable directions, while low amounts of radiation cause the air to move in predictable directions
d. Both high and low amounts of radiation from the sun cause the air to move in spontaneous and unpredictable directions

9) In the Northern Hemisphere, what is the name of the circulation cell located just 30 degrees north of the equator and named after a British amateur meteorologist who was a contemporary of Cook?
a. The Hadley cell
b. The Polar cell
c. The Ferrell cell
d. The Global cell

10) In what direction does air in the Hadley cell move?
a. Diagonally, from the northeast to the southwest
b. Diagonally, from the northwest to the southeast
c. Horizontally, from east to west
d. Horizontally, from west to east

11) What cell, named after an American meteorologist, does the Hadley Cell create by interacting with the air around it?
a. The Ferrell cell
b. The Polar cell
c. The Global cell
d. The Cook cell

12) In what direction does air in the Ferrell cell move?
a. Diagonally, from the southwest to the northeast
b. Diagonally, from the northeast to the southwest
c. Horizontally, from the east to the west
d. Horizontally, from the west to the east

13) What cell interlocks with the Ferrell cell and is located 60 degrees north and upwards?
a. The Polar cell  
b. The Ferrell cell  
c. The Hadley cell  
d. The Global cell  

14) A gyre is a __________________ caused by ______________________.
   a. Circular current; surface winds created by circulation cells in the Northern and Southern Hemispheres  
   b. Circular current; deep currents far below the ocean’s surface  
   c. Pattern of wind; Coriolis Force  
   d. Pattern of wind; surface winds created by circulation cells in the Northern and Southern Hemispheres  

15) Currents can impact all of the following factors EXCEPT what?
   a. Coriolis Force  
   b. Ocean navigation and exploration  
   c. Local economies  
   d. Local weather  

16) Thermohaline currents happen _____________ and regulate _____________.
   a. Deep underwater; the heat balance of our planet  
   b. Deep underwater; the rotation of our planet  
   c. Near the ocean’s surface; the heat balance of our planet  
   d. Near the ocean’s surface; the rotation of our planet  

17) In the process of thermohaline circulation, _______ water sinks and spreads, and water that has sunk is replaced with water from ______ latitudes.
   a. Cold; low  
   b. Cold; high  
   c. Warm; low  
   d. Warm; high  

18) Which of the following factors was NOT listed as a major factor that controls density of seawater?
   a. Viscosity  
   b. Temperature  
   c. Salinity  
   d. Pressure  

19) The sinking in thermohaline currents is caused by changes in _______ and _________.
   a. Temperature and salinity  
   b. Temperature and pressure  
   c. Temperature and Viscosity  
   d. Salinity and Pressure  

20) In the global ocean conveyor, water masses stack up on top of each other according to what factor?
   a. Density
b. Size
c. Salinity
d. Depth

21) What is the interface between two water masses called?
   a. A front
   b. A current
   c. A stream
   d. A gulf

22) Fronts can be __________ mechanisms, impacting the clustering of animal life in the ocean.
   a. Aggregating
   b. Unaffecting
   c. Disconnecting
   d. Unpredictable
VITA

Paige Elizabeth Northern was born June 27, 1995, in Poplar Bluff, Missouri. She is the daughter of Lisa Shoemaker and Anthony Shoemaker. A 2013 graduate of Holcomb High School, Holcomb, Missouri, she received a Bachelor of Science degree with a major in Psychology and minor in German from Southeast Missouri State University, Cape Girardeau, Missouri, in 2016.

After receiving her Bachelor of Science degree, she enrolled in the Experimental Psychology Program at Texas Christian University, where she received her Master of Science degree in 2019. While working on her Master of Science degree, she held a Research Assistantship during the years 2017-2018 and a Teaching Assistantship during the years 2018-2019.

She is married to Donald Joe Northern II of Cape Girardeau, Missouri. They have one child.
ABSTRACT

THE IMPACT OF PRIOR KNOWLEDGE ON STUDENTS’ NOTETAKING, LEARNING, AND JUDGMENTS OF LEARNING

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The impact of reading a text on students’ notetaking during a lecture is a novel issue that has not been examined. According to the generative hypothesis, reading a text prior to viewing a lecture may facilitate processing and aid students’ notetaking. According to the metacognitive hypothesis, reading a text prior to viewing a lecture may cause overconfidence and lead to poor notetaking. In Experiment 1 participants did or did not read a text about to-be-learned material prior to a lecture. Participants gave a judgement of learning (JOL) predicting their memory performance and took a multiple-choice test. Experiment 2 replicated and extended outcomes by adding a group who read an unrelated text prior to watching the lecture. In both experiments, reading a text prior to viewing a lecture did not impact students’ notes, JOLs, or test performance. Overall, reading prior to viewing a lecture does not impact notetaking during a lecture.