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## **Examining the Connections Between Time, Length, and Specificity Factors in Homework and Undergraduate Grade Outcomes**

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I am submitting herewith a dissertation written by Alexander C. Price entitled "Examining the Connections Between Time, Length, and Specificity Factors in Homework and Undergraduate Grade Outcomes." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in School Psychology.

Robert L. Williams, Major Professor

We have read this dissertation and recommend its acceptance:

Robert L. Williams, Robert D. Richardson, Louis M. Rocconi, Sherry M. Bell

Accepted for the Council:

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(Original signatures are on file with official student records.)

Examining the Connections Between Time, Length, and Specificity Factors in Homework and Undergraduate Grade Outcomes

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Alexander Cody Price, M.S.  
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## Abstract

This study was conducted with students previously enrolled in a 200-level educational psychology course from the Fall 2018 and Fall 2019 semesters ( $N = 331$ , students per section ranged from 23 – 31). The purpose of this study was to examine the relationships between time, length, and specificity factors found in homework taken from Canvas on students' homework, exam, and final course grades. The time and length factors taken from a graded homework assignments were used to examine homework scores while the mean values and standard deviation values for these factors taken from all of the homework assignments in a unit were used to examine exam scores. The standard deviation values were used as a measure of consistency among all submitted homework assignments. The specificity factor was created from all of the graded homework assignments and used to examine the final scores in the course.

Several linear mixed models were used to individually examine the relationships between the time and length factors on students' graded homework scores and unit exam scores. A linear regression was used to examine the relationship between the specificity factor and students' final scores in the course. Homework scores were significantly related to exam scores. The results among the time factors yielded some significant relationships, but the significant relationships were not meaningful. The results for the length factors, however, were significant and meaningful. The results for the specificity factor were not significant. Among these factors examined, length factors appear to be the strongest contributor to students' grades.

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## **Chapter 1**

### **Introduction and Literature Review**

Several factors contribute to student success. Among them, time spent outside of class completing homework has been thoroughly researched and shown to contribute significantly to high school and college student achievement (Cooper, 1989; Kitsantas & Zimmerman, 2009; Latif & Miles, 2020; Trautwein, 2007). Successful homework completion depends on several factors that can be examined further. For example, students must decide when to start their homework, how long they will work on their homework, when they will turn their homework in, how long their answers will be, and how specific their answers will be. The use of learning management systems in college classes gives instructors convenient access to detailed data related to these homework factors. Understanding how these homework factors impact student outcomes is the first step in developing interventions to improve course outcomes through the modification of students' decisions related to time, length, and specificity homework factors.

### **Learning Management Systems**

According to Instructure, the owner of Canvas, a learning management system (LMS) can be thought of as “[a] virtual classroom, where you can create, store, share, and communicate” (“The Canvas Learning,” 2021). In a report examining the usage and perspectives regarding learning management systems in the United States, Dahlstrom et al. (2014) reported that “99% of colleges and universities currently report they have an LMS in place.” The most widely used LMS in the United States and Canada is Canvas (Menard, 2019), with Instructure holding 35% of student enrollment by the midpoint of 2019 (Hill, 2019, Aug. 15). Given the prevalence of Canvas and the use of Canvas in the course where this research took place, the remainder of the paper will focus on Canvas specifically.

While a comprehensive review of all the features in Canvas is not necessary for the inquiry presented here, a broad look at prominent features in Canvas will be helpful. A Canvas course contains several sections, such as Files, Quizzes, Announcements, Assignments, Modules, and Grades, within the overall course. Important course documents, PowerPoints, videos, and other resources can be uploaded to the Files section and then to other sections, such as Modules or Quizzes. Instructors can create quizzes and surveys through Quizzes, and course assignments can be listed through Assignments. Instructors and students can track grades through Grades and determine their academic standing. Modules is often used to organize important course materials and assignments chronologically or by specific content areas. Students also have the option to view deadlines within particular courses and across courses they are taking that have course websites on Canvas.

Canvas, as well as other LMSs, collects a wide array of data that can offer new insights into how to improve students' educational performance (Rubel & Jones, 2016). One way of analyzing data collected in Canvas and other LMS is through educational data mining because of the large volume of data collected. According to Romero and Ventura (2010) "Educational data mining (EDM) is a field that exploits statistical, machine-learning, and data-mining (DM) algorithms over the different types of educational data. Its main objective is to analyze these types of data in order to resolve educational research issues" (p. 601). While EDM offers important insights into student outcomes that are not otherwise readily available, it seems unrealistic to expect most instructors to have access to similar resources or the technical skills needed to use EDM to resolve issues specific to their courses. Instead, a broader analysis of homework factors likely to be found in most courses using standard statistical analyses may offer a more accessible approach to remediating students' difficulty with learning course content.

## **Homework Factors**

### **Time Factors**

Among the behaviors that lead to successful homework completion, time factors are particularly easy to track and evaluate through Canvas. Time factors that can be accessed through or calculated from data found in Canvas include when students begin working on their assignments, how long students work on their assignments, and when students submit their assignments. A large body of research has examined the connection between time factors and various student outcomes.

Grave (2011) found a significant relationship between time spent in self-study and grades from a sample of students at German universities collected from 1986 to 2006. Grave also examined the effects of time spent in self-study on grades among various subgroups of students to determine if there were any significant differences based on gender, final high school grades, or field of study. Grave found a significant relationship between time spent in self-study and grades for both males and females with no significant differences between the two. Similarly, Grave found a significant relationship between time spent in self-study and grades among students with different final high school grades, which the author used as a proxy for ability. No significant difference was found between students with lower or higher final high school grades. For field of study, Grave found a significant relationship between time spent in self-study and grades for art/humanities students and social science students, but Grave did not find a significant relationship for science/engineering students.

Keith (1982) examined how student characteristics and time spent on homework affected high school grades. Students were asked to report the average amount of time they spent on homework during a week. Results revealed a positive, statistically significant correlation

between time spent on homework and grades ( $r = 0.32$ ). When other factors, such as ability and field of study, were controlled for, the correlation between time spent on homework and grades was weaker yet still significant ( $r = 0.192$ ).

Research examining procrastination and cramming provides further insights into the relationship between time factors and student outcomes. Steel (2007) defines procrastination as “voluntarily delay[ing] an intended course of action despite expecting to be worse off for the delay” (p. 66) and estimated that around 80-95% of college students procrastinate. In a study examining how different deadlines affect procrastination, Ariely and Wertenbroch (2002) found that students often underestimate the time it takes to complete tasks. They also found that students who produced higher quality work also spent more time working on the assigned task while students who produced lower quality work spent less time working on the assigned task.

The effects of procrastination on educational outcomes for college students is not always consistent though. In their meta-analysis, Kim and Seo (2015) found that procrastination is significantly related to academic performance. When looking at specific academic measures, they found that grade point average (GPA), assignment grades, quiz scores, and course grades were all significantly and negatively correlated with procrastination. Assignment grades had the strongest correlation, and GPA had the weakest correlation. Wesley (1994) reported that procrastination was the second strongest predictor of college grades among high school grades, Procrastination Assessment Scale scores, and SAT scores. SAT scores were the strongest predictor. Procrastination accounted for 12% of the variance in college grades for men and 10% of the variance in college grades for women. Fritzsche et al. (2003) found that procrastination in writing tasks was significantly and negatively correlated with students' GPA ( $r = -.19$ ) and

course grades ( $r = -.21$ ). Tice and Baumeister (1997) indicated that procrastinators received significantly lower grades on exams and a term-paper compared to non-procrastinators.

Other studies examining procrastination have found that only some types of procrastination lead to lower quality work. Chu and Choi (2005) and Westgate et al. (2017) found that different types of procrastination led to different GPAs. Chu and Choi (2005) identified two types of procrastination: active and passive. Active procrastinators are students who intentionally procrastinate and enjoy working under pressure while passive procrastinators are students who do not intend to put off work but do so nonetheless. Active procrastinators have GPAs similar to non-procrastinators, but passive procrastinators tend to have worse GPAs. In a phenomenological study with seven students who met Chu and Choi's definition of an active procrastinator, Hensley (2016) reported that these active procrastinators often reported receiving satisfactory grades (i.e., A's and B's) on papers, assignments, and tests.

Westgate et al. (2017) identified three types of procrastinators: academic productive procrastinators, non-academic productive procrastinators, and classic procrastinators. Academic productive procrastinators procrastinate by putting off one academic task, like homework, in favor of another academic task, like organizing notes. Non-academic productive procrastinators procrastinate by putting off an academic task, like studying, in favor of an important, non-academic task, like laundry or cleaning. Classic procrastinators procrastinate by putting off an academic task, like reading for class, in favor of an unimportant non-academic task, such as browsing social media or watching television. Westgate et al. found no significant difference between non-procrastinators' and academic productive procrastinators' self-reported GPA. Non-academic productive and classic procrastinators, however, had significantly worse self-reported GPA.

Cramming is one method students can use to compensate for procrastinating, and cramming research provides additional information regarding the relationship between time factors and student outcomes. Definitions of cramming vary, but cramming can generally be conceptualized as a large amount of work or studying conducted in a relatively short amount of time before a deadline. Given the variability among the definitions of cramming, prevalence rates can vary, but McIntyre and Munson (2008) asserted that at least 25% of students cram. Furthermore, McIntyre and Munson found that cramming for multiple choice tests in a principles of marketing class led to similar grades as spaced studying. In the long run, however, students who primarily crammed for these multiple-choice tests had lower long-term retention and lower overall GPAs. However, some research suggests that cramming is less detrimental for active procrastinators (Seo, 2012).

### **Length Factors**

The research examining how homework response length affects grade outcomes for college students is limited. In a study examining the effects of an accuracy contingency and a completion contingency on students' homework and exam performance, Galyon et al. (2015) found that students working under an accuracy contingency had significantly better homework and exam grades. They also found that students in the accuracy contingency produced significantly longer answers than students working under the completion contingency.

In a college engineering class, Rawson and Stahovich (2013) gave students Livescribe™ smartpens to track homework habits and build predictive models through DM. They collected data throughout the class but focused their analyses on the data collected during the third homework assignment and associated quiz, as this assignment and quiz reflected the start of the main content coverage for the course. To control for entry knowledge, students were given the



Force Concept Inventory, which measured fundamental physics knowledge. The rest of the data used in the study were collected by the smartpens and included factors such as total time spent on homework, total homework ink (i.e., how much writing students did with the smartpen), average session length (the average time spent on an assignment across separate intervals), and late night ink (the amount of work done from 1:00 – 5:00 A.M.). Rawson and Stahovich built several predictive models with an increasing number of variables included in each model to predict students' final grade in the class (i.e., they measured which 2 factor combinations were the most predictive of final grades, then which 3 factor combinations were most predictive of final grades, and so on up to models with five factor combinations). Across their predictive models, students' Force Concept Inventory scores explained 27% of the variance for final grades. For the data collected by the smartpens, total homework ink was a consistent factor in the most predictive models. The time factors, total time spent, average session length, and late night ink, contributed to some of the less predictive models but were not as predictive of students' final grades as the total homework ink.

Additional research examining the connections between essay characteristics and essay quality also supports a connection between length of responses and outcomes. For example, Korbin et al. (2007) found a significant relationship between the number of words in students' SAT essays and their essay scores. The SAT essays used in the study came from the first 3 administrations of the newly revised SAT, which was first given in March 2005, and were scored by two trained readers who assigned each essay a value from zero to six. Temporary staff then coded for total number of words, total number of paragraphs, and whether the writer used a first-person perspective. The number of words also explained a much higher percentage of the

variance (39%) compared to other factors, such as whether the essay extended into the second page (1.5%) or the perspective taken in the essay (1.1%) (Korbin et al., 2007).

Total word count also significantly contributed to higher essay quality for college students with and without dyslexia. For students with dyslexia, vocabulary, spelling, and handwriting also contributed to their essay scores. The number of words with two or more syllables was the strongest contributor to exam quality while total number of words was the second strongest contributor to exam quality for students with dyslexia (Gregg et al., 2007).

### **Specificity Factors**

At this time, there appears to be very little research pertaining to the relationship between level of specificity in answers to homework questions and grade outcomes. Perhaps this is the case because there is an assumption that students who can produce more specific written responses for homework assignments have a more thorough understanding of the material and are thus more likely to achieve higher grade outcomes compared to students who produce less detailed written responses. While this assumption has high face validity, research should still be conducted to support this assumption. Some support for the connection between level of specificity and higher-grade outcomes can be drawn from other areas of research.

Specificity can be conceptualized in a variety of ways, such as level of detail or breadth vs. depth of knowledge. Regarding level of detail, less specific writings would be considered vague and general while more specific writings would be considered clear and contain more pertinent information. Researchers examining the efficacy of computer-based essay scoring found that essays with more words and phrases associated with “vagueness” correlated with lower scores across several criteria. Essays with more words and phrases associated with “specificity” correlated with higher scores across several criteria. The researchers had some

concern that essay length may have been acting as a confounding variable in this relationship, but after accounting for essay length, the “specificity” variable still had a significant positive correlation with essay scores across several criteria, albeit a bit weaker (Hiller, Marcotte, & Martin, 1969).

In a similar study, Hiller, Fisher, and Kaess (1969) used the same computer-based word tracking to evaluate how the characteristics of high school teachers’ lectures affected students’ learning. Similar to the essay study, lectures with more words and phrases associated with “vagueness” had a significant negative correlation ( $r = -.586$  for a lecture on Yugoslavia, and  $r = -.479$  for a lecture on Thailand) with student learning as measured by a quiz administered after the lecture ended. In fact, vagueness appeared to have the strongest effect on student learning among other factors examined (e.g., lecturer fluency).

Brown and Aull (2017) found that essays with characteristics that matched what they called Elaborated Specificity had higher Advanced Placement English exam scores than essays with characteristics that matched what they called Emphatic Generality. Emphatic generality was described as essays with greater use of “verbs, pronouns, adverbs, and boosters, as well as a narrower generalized vocabulary, and it [the essay] characterizes writing that engaged with a generalized topic” (Brown & Aull, 2017, p. 396). Elaborated specificity was described as essays with greater use of “nouns, articles, prepositions, adjectives, and genitives, as well as a wider discipline specific vocabulary. It [the essay] characterizes writing that tends to focus syntactically and thematically on a specific idea or text and subsequently to elaborate on an idea” (Brown & Aull, 2017, p. 396).

A variety of studies have examined the differential effects of emphasizing depth vs. breadth on student outcomes. Schwartz et al. (2008) investigated how the type of science content

coverage in high school affected students' performance in college introductory biology, chemistry, and physics classes. Students who spent more time on at least one key subject within a field (i.e., greater depth) had higher grades in the corresponding college introductory class. Students who were exposed to all key subjects within a field in high school (i.e., greater breadth) received no benefit in the introductory chemistry and physics classes and performed worse in the introductory biology class. Even after controlling for potential confounding variables, such as student achievement, high school course level, and attendance in high school, the relationships remained significant, albeit weaker. Tweaking the definitions of "depth" and "breadth" did not meaningfully affect the relationships either.

In the college-notetaking literature, Crawford (1925) found positive correlations between number of ideas (i.e., breadth) in students' notes and performance on essay quizzes. A stronger relationship, however, was found between notes that were more detailed and clearer (i.e., depth), rather than vague or brief, and performance on essay quizzes. More recently, Kiewra and Fletcher (1984) found that students who emphasized main ideas in their notes over details had better outcomes. Eggert (2001) found that accuracy in notetaking was a better predictor than completeness or quantity of notes.

In another study examining the effects of breadth vs. depth of vocabulary knowledge on reading comprehension, Kang et al. (2012) found that vocabulary depth was a stronger predictor of reading comprehension for Korean high school English learners. Similar results were found for bilingual children who spoke Spanish and English (Proctor et al., 2012). For native English speakers, however, vocabulary breadth appears to be a stronger predictor for reading comprehension (Pasquarella et al., 2012).

While the connection between specificity in homework responses and the breadth vs. depth research presented here could be considered tenuous, the research examining the differential impact of emphasizing breadth vs. depth in different areas raises questions regarding which instructors should emphasize in which situations. Should students emphasize greater depth in their responses to homework questions? Is there a greater advantage to studying a broader range of concepts in preparation for an exam? How does the type of class affect whether students pursue breadth vs. depth of knowledge? Should students in mathematics classes focus more on depth while students in social sciences focus more on breadth? Will student outcomes be better if depth or breadth is emphasized in primarily discussion-based classes or primarily lecture-based classes? Further research is necessary to answer these questions.

### **Purpose of the Study**

With the use of Canvas and other LMS in higher education, instructors need to utilize these emerging tools to find new ways to improve student performance. Before instructors can more fully utilize these emerging tools, however, a more precise understanding of the effects of different homework factors on course performance is necessary. The data that are accessible in Canvas provide the opportunity to study the nature of these relationships. While EDM and studies like the one conducted by Rawson and Stahovich (2013) offer valuable insights, EDM requires more technical skills and resources that are not likely to be readily accessible to most instructors. An examination of the effects of time, length, and specificity factors in homework on course performance will be more accessible to a broader audience. In the present study, there are several questions about the relationships between homework factors and course grades. The goal of this study is to provide answers to the following questions.

1. How does submitting homework assignments early affect homework and exam scores?

2. How does time spent on homework assignments affect homework and exam scores?
3. How does the time of day homework assignments were submitted affect homework and exam scores?
4. How does the time of day homework assignments were started affect homework and exam scores?
5. How does students' consistency with time factors affect their exam scores?
6. How does the length of students' responses on homework assignments affect their homework and exam scores?
7. How does the consistency of the length of students' responses within a homework assignment and across homework assignments affect their homework and exam scores?
8. How does breadth vs. depth of knowledge in homework responses affect students' final score in the course?

**Chapter II**  
**Methodology**  
**Participants and Setting**

Participants included 331 undergraduate students. The University's Institutional Review Board (IRB) permitted a retroactive examination of all participants' data without obtaining informed consent. One hundred sixty-two students were enrolled in six sections of an educational psychology course during the Fall 2018 semester, and the remaining 169 students were enrolled in six sections of the same educational psychology course during the Fall 2019 semester. All courses took place at a large southeastern university. Demographic data were not available for this study. Only data that were available in Canvas were accessible, and no demographic data were recorded in Canvas for this course. However, students enrolled in this course are typically sophomores and juniors. There are, however, some freshmen and senior students who typically enroll in the course as well.

The majority of students take this course to fulfill a requirement to enter a teacher education program. The remaining students often take the course for general education credit. Each section consisted of 23-31 students. Three graduate teaching associates (GTA) and a full professor instructed the class (referred to as "the course team" from this point forward). The full professor also served as the course supervisor. The same instructors taught the same sections for both the Fall 2018 semester and Fall 2019 semester (i.e., the same instructor taught section one for both the Fall 2018 and Fall 2019 semesters).

**Course Design**

The course consisted of five units, each consisting of four discussion days occurring on Tuesdays and Thursdays during the week, and one exam day, also occurring on a Tuesday or

Thursday. Each unit typically lasted two and a half weeks. Some units, however, were longer due to scheduled University breaks. Grades within each unit included the following categories: attendance, participation, name card, homework assignment, and exams. Regarding the name card grade, students earned 1 point per class if they had a piece of paper with their name written on it displayed on their desks. The purpose for this grade was to help instructors more quickly learn students' names. Students could earn up to 8 points in each unit for attending class, and students could earn up to 12 participation points in each unit for making comments or asking questions in class discussion. Course materials for each unit consisted of a set of instructor notes that served as the textbook for the class, a PowerPoint presentation to supplement the instructor notes, homework questions, one to two supplementary videos with a set of ungraded questions to help students identify the key topics discussed in the video, and audio recordings of each class for students who were unable to attend. The instructor notes, PowerPoint presentations, homework questions, and video questions were all developed by the course team. All course materials were available to students through Canvas at the beginning of the semester. The course team also developed multiple-choice exams that students took at the end of each unit.

Each discussion day had an accompanying set of 15 homework questions designed to be answered after students read the corresponding section of the instructor notes and reviewed the corresponding section of the PowerPoint slides. Most questions required a single response, but some questions had multiple parts for students to respond to (e.g., How are schemes and operations alike and different? Why is one more critical to logical thinking than the other?). Each question could be sufficiently answered with one to four sentences. Each homework assignment was due by 11:59 P.M. the day before class, which were Mondays and Wednesdays. The



homework assignments were designed to prepare students for class discussion and to take the unit exams.

The homework assignments were worth either 5 points or 15 points. Three out of the 4 homework assignments were awarded 5 points as long as they were submitted before the deadline with an answer for each question. The remaining homework assignment was graded for quality and correctness and worth 15 points. At the beginning of each unit, the instructor in each section of the course randomly selected which day would be graded for quality by pulling, or having a student pull, a slip of paper out of a container. Four slips of paper were used, one for each day in the unit, and each slip was marked with a number, 1 through 4. The selected homework assignment was revealed to students on the fourth discussion day after all of the homework assignment deadlines had passed. Each section randomly selected which assignment would be graded in each unit.

Unit exams consisted of 50 multiple choice questions that covered the critical information in each unit. Each discussion day had roughly equal representation in the exam (i.e., 11 – 14 questions from each discussion day). Students had the full class period, 75 min, to take the exam, and scratch paper was offered to students who wanted it. Students received immediate feedback about their grade on the exam and were given the opportunity to silently review their answers before leaving the classroom. Students who missed exams were often given the opportunity to make up the exam depending on the reason for the absence. The same procedures used in the regular exam were also used with makeup exams with the only difference being that students took the exam in the instructor's office.

## **Semester Differences**

While the major features and content of the course were consistent between the Fall 2018 and Fall 2019 semesters, some notable differences both within and between semesters are reported here. The only difference between the semesters regarding the homework factors examined in this study was that data related to when students started their homework assignments and how long they spent working on their assignments was only available for the Fall 2019 semester. There were no other differences between the other homework factors collected for the Fall 2018 and Fall 2019 semesters.

In the Fall 2018 semester, the homework questions were available to students online through Canvas in a Microsoft Word document. Students were required to submit the answers to the homework questions through Canvas by copying and pasting all of the questions and all of their answers into a text box for each day's assignment. In the Fall 2019 semester, the homework questions were available to students online using the Canvas Quizzes section. Students were required to open the quiz, view the questions, type each answer to each question into individual textboxes, and then submit their responses.

In the Fall 2018 semester, students submitted their answers to exams by filling out a scantron form provided by their instructor. The instructors scored each students' exam once they finished and gave the scored scantron back to students to review. Students gave their scantrons back to their instructor before leaving. In the Fall 2019 semester, students submitted their answers to exams through a Canvas quiz. The exams were taken in a computer lab on campus. The computers in the computer lab were also equipped with Respondus Lockdown Browser, an exam security software used with Canvas. Students received immediate feedback after submitting their exams. It should be noted, however, that the students in the third and fourth

sections of the course in the Fall 2019 semester did not take their exams on the computer in the computer lab due to a scheduling conflict. Students in the third and fourth sections took their exams with scantrons in the classroom, similar to the students in the Fall 2018 semester.

Some content changes also occurred between the two semesters. In the third unit of the course, information related to character education was removed for the Fall 2019 semester. Information related to climate change and immigration was added to the third unit in that semester as well. In the fourth unit, the order in which the information was presented changed. Topics related to Behaviorism, reinforcement, and punishment were moved to earlier in the unit while information related to educational disabilities and reading instruction was moved to later in the unit. Aside from these changes, minor editorial changes in each unit were made as well. Some exam items and homework questions were exchanged or edited to improve clarity. The vast majority of the course content, however, remained the same.

### **Procedures**

All of the information used for data analysis was collected from Canvas. Grade-related information came from each section's gradebook. Data related to the final exam for the course were not collected or examined because not every student took the final exam. Students who demonstrated exemplary work throughout the course were not required to take the final exam. Most homework-related information came from SpeedGrader, Canvas's homework grading tool. For the Fall 2018 semester, the remaining homework information came from downloading the students' homework submissions. Additional homework related information for the Fall 2019 semester came from a downloaded Student Analysis report available through the Canvas's Survey Statistics function, explained in greater detail later. Every file downloaded from Canvas was encrypted with VeraCrypt, a third-party encryption tool. After all student data were

aggregated into a single file, all identifying information was removed, students were randomly sorted within their sections to further limit access to identifying information through backtracking, and any remaining files with identifying information were deleted from the computer on which they had been stored.

### **Fall 2018**

As stated previously, all grade-related information was collected by downloading each section's gradebook. The time an assignment was submitted (referred to as "time of submission" from this point forward) and number of minutes an assignment was submitted early (referred to as "time until the deadline" from this point on) were collected from Canvas's SpeedGrader. On the homework assignment graded for quality (referred to as "graded homework" from this point on), the number of full points, -0.5 points, and -1 points were manually collected from the instructor feedback for each student. A small number of homework questions were awarded an irregular number of points (e.g., 0.8 points). These data were removed to maintain consistency across units and sections. Additionally, there were a small number of inconsistencies between the number of points awarded within the graded homework and the number of points awarded in the gradebook. The affected homework grades were changed to match the number of points originally recorded within the graded homework. To collect the total number of words for each answer in each homework assignment (referred to as "response length" from this point on), the student submissions were downloaded and opened in Microsoft Word. Each answer was then highlighted to record the response length for each answer for each assignment.

### **Fall 2019**

In the Fall 2019 semester, students worked more directly in Canvas, which enabled Canvas to collect information that was manually processed for the Fall 2018 semester. The

majority of students' homework-related data were collected through the Student Analysis report. The Student Analysis report transfers several types of student data from Canvas into an Excel spreadsheet. The information transferred included the students' first and last names, their ID number, their section number, the time of submission for that homework assignment, recorded as yyyy-mm-dd hh:mm:ss in Coordinated Universal Time (UTC), the number of quiz attempts, each question, and their responses to each question. The data transferred to Excel needed cleaning because the students' responses picked up several odd letters and symbols not found in their original responses (e.g., apostrophes were replaced with "TM). After fixing these errors, the response length was calculated using a word count formula in Excel (see appendix A). Several students' responses were checked in both Excel and Word to ensure similar results from the different methods used to obtain the total word count.

In addition to the time of submission, Canvas's SpeedGrader also reports the total time students spent completing each homework assignment (referred to as "time spent" from this point forward) since the homework assignments in the Fall 2019 semester were set up to be Canvas quizzes. The time spent was manually transferred from Canvas to a time converter template the primary investigator created to calculate the pertinent time variables (see appendix A). To determine the time of submission in Eastern Standard Time, in addition to all of the other time variables assessed in this study, the time of submission in UTC, the due date of the homework assignment, and time spent were entered into the Excel.

In the Student Analysis report, the data were ordered by the time of submission while the data in the gradebook was ordered alphabetically according to students' last names. The data provided by the Student Analysis report were properly sorted to match the gradebook order using the students' ID numbers. Then, data from the Student Analysis report were copied and pasted

into the primary investigator's Excel time converter template. The time spent taken from Canvas's SpeedGrader was also entered into the time converter template. From there, the time of submission and start time were changed to EST. The time until the deadline and whether or not the homework assignment was late were also calculated. For the graded homework, the number of full points, -0.5 points, and -1 points were mostly collected from the instructor feedback in SpeedGrader the same way these data were collected for the Fall 2018 semester. In one section, however, the number of full points, -0.5 points, and -1 points were collected from the Student Analysis reports instead of SpeedGrader because instructor feedback for how many points had been deducted was lost for some homework assignments. Errors in grading between the scores reported in the homework assignments and in the gradebook were corrected for this semester as well (i.e., the score based on instructor feedback in SpeedGrader was different than what had been entered into the gradebook).

### **Variable Creation**

Several variables were created after aggregating the data collected from Canvas. The mean and standard deviation for each of the time and length factors were calculated for analyses in examining unit exam scores. Standard deviations were calculated to be a measure of consistency across students' all homework assignments submitted within a unit, not just the graded homework (e.g., students who consistently started their homework at the same time each day would have a smaller standard deviation value than a student who start their homework at vastly different times). For each unit, means and standard deviations were only calculated for students who had at least 2 out of 4 on-time homework submissions. Additional steps had to be taken to calculate the means and standard deviations for the start time and time of submission factors. The typical mean and typical standard deviation formulas do not correctly recognize that

the times shortly before and after midnight are actually close together. For example, 11:55 P.M. and 12:05 A.M. are only separated by 10 min, but the typical mean formula would report that the mean for these two times is 12:00 P.M. instead of 12:00 A.M. The following decision rules were used to calculate the correct values for time of submission and start time:

1. If a student's times were all in the A.M. or P.M., then the typical formulas were used.
2. If a student's times were split between the A.M. and P.M. and the sum of the distance for each submission to noon was smaller than the distance to midnight, then the typical formulas were used.
3. If a student's times were split between the A.M. and P.M. and the sum of the distance for each submission to midnight was smaller than the distance to noon, then an alternative mean formula was used (see appendix A). The standard deviations for these cases were calculated after adding 24 hr to any values that were in the A.M.

Additional changes had to be made to the response length due to a course error in the Fall 2019 semester. In the fourth unit of the Fall 2019 semester, the third and fourth homework assignments only had 14 and 13 questions, respectively. To correct this issue, the response length for each homework assignment was divided by the total number of questions in that homework assignment (i.e., most were divided by 15, but the third and fourth homework assignments in the fourth unit in the Fall 2019 semester were divided by 14 and 13, respectively). The resulting values represented the mean number of words per question (referred to as "words per question" from this point forward).

For the purpose of this study, specificity was conceptualized as breadth vs. depth of knowledge. Students who earned predominantly -0.5 points throughout the course were seen as having a greater breadth of knowledge while those earned predominantly -1 points throughout

the course were seen as having a greater depth of knowledge. For example, two students may have the same homework score of 14, but one student may could receive 2 -0.5 points while the other could receive one -1 point. The student who has two -0.5 points has some understanding of the topics related to the 2 missed questions but not a complete understanding. The student who has one -1 point has a greater understanding of the topics related to the 14 questions answered correctly but limited to no understanding of the one question answered incorrectly.

A specificity factor was created for each student to indicate whether they tended to earn more -0.5 points or -1 points on the graded homework. For each unit, students were assigned either a 0 for receiving mostly -0.5 points on the graded homework or a 1 for receiving mostly -1 points on the graded homework. These scores were then averaged to provide a score ranging from 0 to 1. The graded homework with 15 correct points or an equal number of -0.5 and -1 points were excluded from the calculations used to make this specificity factor.



## **Chapter III**

### **Results of the Study**

#### **Analysis Plan**

A repeated measures linear mixed model was used to examine the effects of the time and length factors on homework and unit exam scores. The units and course sections were included as fixed effects to control for variability in homework and exam scores between units and sections. The first analysis for each factor included the interaction between unit and the independent variable. If no significant interaction effect was found, the interaction was removed, and the analysis was run again to determine if there was a significant main effect. If a significant interaction effect was found, a simple effects analysis was conducted to determine in which units there were significant effects of the independent variable on the dependent variable. A linear regression was used to examine the effects of the specificity factor on students' final score in the course while controlling for students' mean graded homework scores.

#### **Data Cleaning Procedures**

Prior to running any analyses, data from any late homework submissions were removed before creating any additional variables or running any analyses. Out of the 6,464 assignments across for every homework assignment in each unit, 198 assignments were submitted late. The data for the time until the deadline factor and time spent factor were trimmed at the 98<sup>th</sup> percentile to remove extreme outliers (e.g., students who submitted a homework assignment weeks in advance). For the time until the deadline factor, 151 assignments had times until the deadline greater than the 98<sup>th</sup> percentile. For the time spent factor, 64 assignments had times spent greater than the 98<sup>th</sup> percentile. The remaining data for the other time factors, length

factors, and specificity factors were not trimmed because there were no unrealistic cases in need of removal.

The primary investigator also removed seven students' data from the sample due to almost a complete absence of homework assignments or because the students dropped out of the class. The normality, homoscedasticity, and linearity of the residuals from each mixed model were examined to determine if the assumptions for the mixed model analysis had been met. Cases with large residual values revealed during the assumption checks were also profiled to ensure that only valid cases were included in the analyses. Cases that were profiled and found to be invalid were removed from the analyses. For example, students who only submitted one-word answers to a majority or all of their homework questions were removed. Only six assignments were excluded from analyses examining the graded homework scores. Students who earned 0's on their homework and exams were also removed as these cases represented instances of a failure to submit their homework or to take their exam rather than a genuine score of 0. Only three exams and two homework assignments had scores of 0. Table B1 represents the total number of participants in each unit and section after data cleaning.

### **Descriptive Statistics**

All descriptive data related to the homework assignments only include the cases that were not removed during the data cleaning procedures. The mean scores across units and sections for the graded homework and unit exams for each unit and section are represented in Tables B2 and B3, respectively. The mean graded homework scores across units and sections ranged from 11.09 to 14.6 out of a possible 15 points. The mean unit exam scores across units and sections ranged from 38.9 to 44.9 out of a possible 50 points. The mean percentages for the final scores for each section can be found in table B4. The mean final scores ranged from 82.0% to 91.3%.

The mean time until the deadline (TTD-G), time spent (TS-G), time of submission (TOS-G), and start time (ST-G) for the graded homework in each unit and section are represented in Tables B5, B6, B7, and B8, respectively. The mean TTD-G across units and sections ranged from 173.7 to 1522.4 min. The mean TS-G across units and sections ranged from 113.7 to 1076.7 min. The mean TOS-G across units and sections ranged from 5:27 P.M. to 11:27 P.M. The mean ST-G across units and sections ranged from 5:21 P.M. to 12:16 A.M.

The mean time until the deadline (TTD-A), time spent (TS-A), time of submission (TOS-A), and start time (ST-A) for all homework assignments in each unit and sections are represented in Tables B9, B10, B11, and B12, respectively. Standard deviations were also calculated for each of these variables as a measure of consistency across all homework assignments submitted in a unit (referred to as “consistency” from this point forward). A higher consistency value indicates greater variability while a lower consistency value indicates lower variability. The mean consistency for these factors in each unit and section are represented in Tables B13, B14, B15, and B16, respectively. The mean TTD-A across units and sections ranged from 252.8 to 1156.3 min. The mean TTD-A consistency across units and sections ranged from 162.9 to 1074.2. The mean TS-A across units and sections ranged from 224.7 to 928.6. The mean consistency for TS-A across units and sections ranged from 187.2 to 910.6. The mean TOS-A across units and sections ranged from 6:20 P.M. to 9:30 P.M. The mean TOS-A consistency across units and sections ranged from 91.4 min to 184.9 min. The mean ST-A across units and sections ranged from 4:44 P.M. to 8:41 P.M. The mean consistency for ST-A across units and sections ranged from 120.5 min to 204.3 min.

The mean words per question in students’ responses only for the graded homework (WPQ-G) in each unit is represented in Table B17. The mean WPQ-G across units and sections

ranged from 28.1 to 59.0. The mean words per question in students' responses for all of the homework assignments in each unit (WPQ-A) is represented in Table B18. The mean WPQ-A across units and sections ranged from 31.8 to 53.7. The mean consistency for WPQ-G is represented in Table B19. The mean consistency for WPQ- G across units and sections ranged from 10.7 to 28.6. The mean consistency for WPQ-A is represented in Table B20. The mean consistency for WPQ-A across units and sections ranged from 5.0 to 10.4.

The distribution of students who earned predominantly -0.5 points or -1 points on their graded homework by unit and section is represented in Table B21 for the Fall 2018 semester and Table B22 for the Fall 2019 semester. Across both the Fall 2018 and Fall 2019 Semester, most students in most sections predominantly earned -0.5 points. The number of students who predominantly earned -0.5 points ranged from 6 to 30. The number of students who predominantly earned -1 points ranged from 0 to 18. The mean specificity score earned in each section is represented in Table B23. The mean specificity score ranged from 0 to 0.4.

### **Preliminary Analysis**

A repeated measures linear mixed model with an unstructured covariance structure was used to examine the effect of the graded homework scores on the unit exam scores. Indicator variables for unit and section were included in the analysis to control for variable performance among the units and sections. The repeated measure in this analysis was the five units in the course. The mixed model analysis maintained the direct relationship between the independent and dependent variables within each unit instead of averaging the data across all five units. The analysis examining the effect of graded homework score on unit exam score was also run with a first-order autoregressive (AR1) covariant structure and a diagonal (DG) covariant structure, but

the unstructured (UN) covariant structure yielded the lowest Akaike's Information Criterion (AIC) value, and thus, determined to fit the data the best.

The assumptions of normality, homoscedasticity, and linearity were checked through visual analysis of a histogram for the standardized residuals, a scatterplot examining the predicted outcomes with the residuals, and a scatterplot examining the unit exam scores with the residuals, respectively. Before examining the relationships between the time and length factors and students' grades, a preliminary analysis was run to determine whether or not homework scores were significantly related to exam scores. If homework scores were not significantly related to exam scores, the justification for examining the relationships between components of homework and exam scores would be not be as justified. No significant interaction effect was found between the graded homework scores and unit,  $F(4, 444.682) = 2.052, p = .086$ . There was, however, a significant main effect for the graded homework scores and unit exam scores,  $F(1, 1398.486) = 55.574, p < .001$ . For every point students earned on the graded homework, their exam scores increased by 0.54 points.

### **Time Factor Analyses**

Analyses examining the students' graded homework scores used data taken from the graded homework within each unit, and analyses examining the students' exam scores used data taken from all homework assignments submitted within a unit. Unit and section were included in the analyses to control for variable performance among the units and sections. Repeated measures linear mixed models with an UN covariant structure were used to individually examine the effects of TTD-G, TS-G, TOS-G, and ST-G on students' graded homework scores and the effects of TTD-A, TS-A, TOS-A, and ST-A on students' unit exam scores. The repeated measure for these analyses were the five units in the class. For each mixed model, the UN covariant

structure yielded the lowest AIC value among the AR1, DG, and UN covariant structures. Each of the analyses satisfied the normality, homoscedasticity, and linearity assumptions based on visual analysis of a histogram for the standardized residuals, a scatterplot examining the predicted outcomes with the residuals, and a scatterplot examining the graded homework scores with the residuals, respectively.

### **Research Question #1: How does Submitting Homework Assignments Early Affect Homework and Exam Scores?**

Results of the analysis examining the interaction between unit and TTD-G on students' graded homework scores were not significant,  $F(4, 550.357) = 0.168, p = .955$ . The main effect of TTD-G on students' graded homework scores was not significant either,  $F(1, 1100.299) = 0.1170, p = .732$ . The results of the analyses examining the mean TTD-A on unit exam scores did not yield a significant interaction effect,  $F(4, 452.367) = 1.480, p = .207$ , but the main effect of the mean TTD-A on unit exam scores was significant,  $F(1, 1272.491) = 4.275, p = .039$ . For every one-minute increase in students' mean TTD-A, their exam scores increased by 0.00035.

### **Research Question #2: How does Time Spent on Homework Assignments Affect Homework and Exam Scores?**

The interaction between unit and TS-G on students' graded homework scores was not significant,  $F(4, 291.700) = 0.453, p = .770$ . The main effect of TS-G on students' graded homework scores was not significant either,  $F(1, 596.844) = 0, p = .998$ . Even after trimming the data at the 98<sup>th</sup> percentile, the upper range for the TS-G factor was still around 6,000 min (i.e., around 4 days). Three additional analyses were run after limiting the TS-G factor to students who spent 1 hr or less ( $N = 109$ ), 2 hr or less ( $N = 148$ ), and 3 hr or less ( $N = 156$ ) on their graded homework. There were no significant main effects or interaction effects for the analyses

examining the 1 hr or less group,  $F(1, 10.724) = 0.177, p = .682$  and  $F(4, 20.043) = 0.962, p = .450$ , respectively, or the 3 hr or less group,  $F(1, 414.794) = 0.120, p = .729$  and  $F(4, 162.233) = 1.348, p = .254$ , respectively.

There was a significant interaction between unit and TS-G for the 2 hr or less group on students' graded homework scores,  $F(4, 120.419) = 2.717, p = .033$ . A simple effects analysis was conducted and revealed that there was only a significant connection between the 2 hr or less group and the third unit. Students' graded homework scores slightly increased in the third unit for each additional minute spent working on the graded homework. See Table B24 for the estimated values and significance for each unit.

The results of the analysis examining the mean TS-A on unit exam scores yielded neither a significant interaction nor a significant main effect,  $F(4, 229.679) = 2.333, p = .057$  and  $F(1, 710.117) = 0.753, p = .386$ , respectively. Similar to the analyses examining the graded homework scores, three additional analyses were conducted after limiting the TS-A factor to students who on average spent 1 hr or less ( $N = 64$ ), on average 2 hr or less ( $N = 113$ ), and on average 3 hr or less ( $N = 131$ ) on all of their graded homework in a unit. No significant main effect was found for the average of 1 hr or less group,  $F(1, 87.620) = 0.583, p = .447$ . When the interaction between TS-A and unit for the average of 1 hr or less group was included in the analysis, the model failed to achieve convergence. No significant results were found for the average of 2 hr or less group on unit exam scores for either the main effect,  $F(1, 271.973) = 0.035, p = .853$ , or the interaction effect,  $F(4, 85.967) = 0.951, p = .439$ . There were also no significant results for the average of 3 hr or less group on unit exam scores for either the main effect,  $F(1, 346.826) = 0.153, p = .696$ , or the interaction effect,  $F(4, 134.139) = 0.372, p = .828$ .

**Research Question #3: How does the Time of Day Homework Assignments were Submitted Affect Homework and Exam Scores?**

The results of the analysis examining the interaction effect between TOS-G and unit on students' graded homework scores were not significant,  $F(4, 553.627) = 0.013, p = 1.0$ , but the main effect of TOS-G on students' graded homework scores was significant,  $F(1, 1132.547) = 6.950, p = .008$ . For every minute later in the day students submitted their graded homework, their graded homework scores were 0.00034 points lower. The results of the analyses examining the interaction effect for mean TOS-A and unit on unit exam scores was not significant,  $F(4, 485.209) = 1.219, p = .302$ . There was no significant main effect of the mean TOS-A on unit exam scores,  $F(1, 1430.435) = 2.499, p = .114$ .

**Research Question #4: How does the Time of Day Homework Assignments were Started Affect Homework and Exam Scores?**

The results of the analysis examining the interaction effect of ST-G and unit on students' graded homework scores were not significant,  $F(4, 253.348) = 1.106, p = .354$ . However, the main effect of ST-G on students' graded homework scores was significant,  $F(1, 612.336) = 4.613, p = .032$ . For every minute later in the day students started their graded homework, their graded homework scores were 0.00038 points lower. The results examining the main effect for mean ST-A on unit exam scores were not significant,  $F(1, 638.033) = 3.362, p = .067$ , and the interaction effect between the mean ST-A and unit on unit exam scores was not significant either,  $F(4, 275.413) = 0.272, p = .896$ .



### **Research Question #5: How does Students' Consistency with Time Factors Affect Exam Scores?**

There was a significant interaction effect between consistency TTD-A consistency and unit on unit exam scores,  $F(4, 485.262) = 2.396, p = .05$ . A simple effects analysis was conducted and revealed that students' unit exam scores were only significantly affected in the second and fifth units,  $p = .013$  and  $p = .043$ , respectively. See Table B24 for the estimated values for each unit. Neither the interaction effect of TS-A consistency nor the main effect between TS-A consistency and unit were significantly related to unit exam scores,  $F(1, 687.363) = 1.874, p = .172$  and  $F(4, 284.424) = 1.883, p = .113$ , respectively. There was not a significant main effect of TOS-A consistency on unit exam scores,  $F(1, 1437.371) = 1.922, p = .166$ . There was also not a significant interaction effect between TOS-A consistency and unit on unit exam scores,  $F(4, 505.941) = 0.848, p = .495$ . There were no significant results for either the main effect of ST-A consistency on unit exam scores,  $F(1, 691.067) = 0.001, p = .978$ , or the interaction effect of ST-A consistency and unit on unit exam scores,  $F(4, 280.765) = 1.124, p = .345$ .

### **Length Factor Analyses**

A repeated measures linear mixed model with an UN covariance structure was used to individually examine the effects of the WPQ-G and the consistency of students' response length in their graded homework on their graded homework scores. Each of the analyses satisfied the normality, homoscedasticity, and linearity assumptions based on visual analysis of a histogram for the standardized residuals, a scatterplot examining the predicted outcomes with the residuals, and a scatterplot examining the graded homework scores with the residuals, respectively. Some

slight heteroscedasticity and ceiling effects were observed in the visual analysis of the scatterplot examining the predicted outcomes with the residuals.

A repeated measures linear mixed model with an UN covariant structure was also used to individually examine the effects of the mean and standard deviation of WPQ-A on unit exam scores. Each of the analyses satisfied the normality, homoscedasticity, and linearity assumptions based on visual analysis of a histogram for the standardized residuals, a scatterplot examining the predicted outcomes with the residuals, and a scatterplot examining the unit exam scores with the residuals, respectively.

#### **Research Question #6: How does the Length of Students' Responses on Homework Assignments Affect Their Homework and Exam Scores?**

There was a significant interaction effect between WPQ-G and unit on students' graded homework scores,  $F(4, 385.830) = 5.562, p < .001$ . A simple effects analysis was conducted and revealed that students' graded homework scores were significantly affected in every unit,  $p < .001$ . Across all five units, an increase in the length of students' answers translated to an increase in their graded homework score. See Table B24 for the estimated values for each unit.

The interaction between mean WPQ-A and unit on unit exam scores was not significant,  $F(4, 369.981) = 0.917, p = .454$ . However, the result of the analysis examining the main effect of mean WPQ-A on unit exam scores was significant,  $F(1, 967.388) = 51.729, p < .001$ . For every one-point increase in students' mean WPQ-A, their unit exam score increases by 0.069.

#### **Research Question #7: How does the Consistency of the Length of Students' Responses on Homework Assignments Affect Their Homework and Exam Scores?**

There was a significant interaction effect between response length consistency and unit on the graded homework scores,  $F(4, 503.468) = 3.966, p = .004$ . A simple effects analysis was

conducted and revealed that the response length consistency and students' graded homework scores were only significantly related in units 1-4. For these units, students' graded homework scores increased for each additional point increase in their response length consistency. See Table B24 for the estimated values for each unit. Neither the main effect of WPQ-A consistency on unit exam scores nor the interaction effect between WPQ-A consistency and unit on unit exam scores were significant,  $F(1, 1300.636) = 0.094, p = .760$  and  $F(4, 515.495) = 1.221, p = .301$ , respectively.

### **Specificity Factor Analyses**

Linear regressions were used to examine how students' specificity scores affected their final scores in the course. Each of the analyses satisfied the normality, homoscedasticity, and linearity assumptions based on visual analysis of a histogram for the standardized residuals, a scatterplot examining the predicted outcomes with the residuals, and a scatterplot examining the final scores with the residuals, respectively. Because students' specificity scores were derived from their graded homework, the average score for students' graded homework across all five units was included in the regression to control for the effect of students' graded homework scores on their final scores.

### **Research Question #8: How does Breadth Vs. Depth of Knowledge in Homework Responses Affect Students' Final Score in the Course?**

Students' specificity scores were not significant predictors of their final scores in the course,  $b = 0.011, t(315) = 0.254, p = .800$ . An additional regression analysis was run that excluded the first, second, and third sections of the Fall 2018 semester and the second, third, and fourth sections of the Fall 2019 semester. These sections were removed because the specificity scores were either practically 0 or 0 (i.e., a specificity score of 0 means that the student only ever

received mostly -0.5 points on the graded homework). However, students' specificity scores were still not significant predictors of their final scores in the course,  $b = 0.046$ ,  $t(146) = 0.695$ ,  $p = .488$ .

## **Chapter IV**

### **Discussion**

The primary goal of this study was to examine how time, length, and specificity factors collected from data available in Canvas affected undergraduate students' grade outcomes. In this sample, students' graded homework scores were significantly related to their exam scores, mirroring the results from Cooper (1989), Kitsantas and Zimmerman (2009), Latif and Miles (2020), and Trautwein (2007). Time and length factors were used to examine students' performance on the graded homework and unit exams, while the specificity factor was used to examine overall performance in the course. Between the time and length factors, length appeared to have more meaningful connections to the graded homework and unit exam scores than time. Among the time factors, there were fewer factors that were significantly related to both the graded homework and exam scores. The specificity factor was not significantly related to students' final score in the class, but there were some notable concerns for this factor that will be discussed later.

### **Time Factors**

#### **Research Question #1: How does Submitting Homework Assignments Early Affect Homework and Exam Scores?**

Based on these results, there was not a significant relationship between time until the deadline and the graded homework scores. There was a significant, albeit not meaningful, relationship between time until the deadline and unit exam scores. With a 0.00035-point increase in exam scores for every additional minute on average a student submitted their homework early, a student would have needed to submit their assignments almost 2 days early on average to equal

a 1-point increase in their unit exam scores. Out of 1619 cases, there were only 33 cases where students had an average time until the deadline of greater than 2 days.

## **Research Question #2: How does Time Spent on Homework Assignments Affect**

### **Homework and Exam Scores?**

Time spent was not significantly related to the graded homework scores or unit exam scores. This result should be interpreted with caution, however, due to a problem with Canvas's method for calculating time spent. Canvas records the total amount of time that elapses from the moment a quiz is started to when it is turned in. Thus, the time spent factor was not accurately measuring how long students were actually working on their assignments since Canvas does not stop recording the time spent when students stop working or navigate away from Canvas. Further analyses were run after only including more realistic times (e.g., up to 1 hr, 2 hr, and 3 hr), but these analyses did not yield any significant main effects.

There was a significant interaction effect between time spent and unit on the graded homework scores for students who spent 2 hr or less on their homework. The graded homework scores were only significantly related to time spent in the third unit. Because students could only receive 0.5 points and 1 points on the graded homework, a student would have needed to spend an additional 84 min to earn 1 additional point.

## **Research Question #3: How does the Time of Day Homework Assignments were Submitted Affect Homework and Exam Scores?**

The average time of submission for homework did not have a significant relationship with students' exam scores. While time of submission for the graded homework had a significant relationship with the graded homework scores, the relationship was not meaningful. A 23-hr difference in time of submission would have been necessary to result in a 0.5-point change in a

student's homework grades. In other words, students who submitted their homework assignments around 12:00 – 1:00 A.M. were more likely to have slightly higher scores compared to students who submitted their assignments around 11:00 – 11:59 P.M. Out of 1,569 graded homework, only 8 were submitted between 12:00 A.M. and 1:00 A.M.

#### **Research Question #4: How does the Time of Day Homework Assignments were Started Affect Homework and Exam Scores?**

Similar to time of submission, the average start time was not significantly related to students' unit exam scores. Start time had a significant, but not meaningful, relationship with students' graded homework scores. A 22-hr difference in start time would be necessary to result in a 0.5-point change in a student's graded homework scores. In other words, students who started their homework assignments around 12:00 – 2:00 A.M. were more likely to have slightly higher scores compared to students who started their homework assignments around 10:00 – 11:59 P.M. Out of 803 graded homework, only one student started their homework between 12:00 – 2:00 A.M.

#### **Research Question #5: How does Students' Consistency with Time Factors Affect Exam Scores?**

Only time until the deadline consistency had a significant relationship with unit exam scores, and the relationship was only significant for the second and fifth units. While the results were significant, they were not meaningful. Students in the second unit would have needed their time until the deadline standard deviation to be at least 1,261 min to equal a 1-point increase on their exam scores, and students in the fifth unit would have needed their time until the deadline standard deviation to be at least 1,792 min to equal a 1-point increase on their exam scores. Out

of 327 students, 29 had a time until the deadline consistency higher than 1,261 min in the second unit, and 27 students had a time until the deadline consistency higher than 1,729 min.

Most of these findings stand in contrast to the results of procrastination research, where delayed work is related to worse outcomes (Ariely & Wertenbroch, 2002; Fritzsche et al., 2003; Tice & Baumeister, 1997) and other time-related research where greater time spent on homework was related to better grades (Grave, 2011; Keith, 1982). While there were some significant results in this study, the potential impact on students' scores was minimal or limited to individual units. It is currently unclear why some results vary by unit, but there are several possible explanations, such as inherent differences among the units, students' familiarity or interest in the material, or outside workload. At present, however, there is not an obvious reason that provides a satisfactory explanation for the varying results.

One explanation for these findings could be the presence of active procrastinators who meet the definitions put forth by Chu and Choi (2005) or Westgate et al. (2017). A visual inspection of the scatterplot for the time remaining until the deadline and students' homework and unit exam scores revealed that several students who submitted their homework right before the deadline received very high scores. One might also argue that these findings are supported by the conclusions from McIntyre and Munson's (2008) and Hensley's (2016) research that students who cram often receive satisfactory grades on their assignments.

### **Length Factors**

#### **Research Question #6: How Does the Length of Students' Responses on Homework Assignments Affect Their Homework and Exam Scores?**

Students' graded homework scores significantly increased as response length increased in every unit. The main effect of the average response length was also significantly related to unit



exam scores. For both the graded homework scores and unit exam scores, however, there was a ceiling effect because students could only earn up to 15 points on the graded homework and 50 points on the unit exams. See Tables B25 and B26 for more information on how response length affected the graded homework scores and unit exam scores.

**Research Question #7: How does the Consistency of the Length of Students' Responses on Homework Assignments affect Homework and Exam Scores?**

There was not a significant relationship between response length consistency and unit exam scores, but there was a significant interaction effect between response length consistency and scores on the graded homework. Students' graded homework scores increased as response length became less consistent in each unit. While not as apparent compared to response length, there was also a noticeable ceiling effect for response length consistency. See Table B27 for more information on how response length consistency affected graded homework scores.

These findings closely match the research examining the relationship between writing length and writing outcomes. While prior research examining the relationship between response length in homework and grades was not found, the significant results found in this study that greater response length is significantly related to higher graded homework scores and unit exam scores matches the general conclusion that greater writing length is significantly related to higher scores for various types of writing assignments (Galyon et al., 2015; Gregg et al., 2007; Korbin et al., 2007; Rawson & Stahovich, 2013).

However, the inverse relationship between response length consistency and graded homework scores was unexpected. As a reminder, higher values for response length consistency indicate greater variability among response length. Students who had greater response length consistency tended to have higher graded homework scores. One possible explanation for this

finding could be the close relationship between response length and response length consistency. The correlation between response length and response length consistency was significant at the 0.001 level and yielded a Pearson's  $r$  of 0.705; students who wrote more tended to have greater variability when it came to the length of their answers. Another possible explanation could be that greater response length consistency was indicative of students paying more attention and matching their response length to the level of information needed to sufficiently answer each question. Students who provided shorter and more general answers may have been more likely to produce more consistent response lengths than students who provided more appropriate answers.

### **Specificity Factors**

#### **Research Question #8: How does Breadth Vs. Depth of Knowledge in Homework**

#### **Responses Affect Students' Final Score in the Course?**

While other studies have found significant effects for students' breadth or depth of knowledge (Kang et al., 2012; Pasquarella et al., 2012; Schwartz et al., 2008), there was not a significant relationship between students' specificity score and their overall course grades while controlling for average graded homework scores. Six out of the 12 sections were removed from the analyses because these sections had little to no variability among students' specificity scores. Even after removing these sections, the results were still not significant.

On the surface, these results would suggest that there are no significant differences in the overall course outcomes between students who tended to receive more -0.5 points on their graded homework, which was classified as greater breadth of knowledge, and students who tended to receive more -1 points on their graded homework, which was classified as greater depth of knowledge. There were, however, several problems with the specificity factor that limit the ability to draw sound conclusions. These limitations are discussed in more detail later.

## **Limitations and Future Research**

Some general limitations for this study included a lack of demographic information and additional course factors, such as time spent on and method for studying, engagement in class discussion, measures of prior ability, student motivation, and level of student cooperation, that could affect course grades. Because the data used in the study were retroactively collected, information was limited to what could be taken from Canvas. Additionally, each of the time, length, and specificity factors were examined individually. No analyses were conducted examining the potential interactions within or among the time, length, and specificity factors on students' homework, exam, or final course scores. Future research should examine information related to student demographics and other course factors. Furthermore, the potential interactions among the time, length, and specificity factors on students' graded homework, unit exam, and final scores in the course should be explored. The interactions between time and length factors on students' grades in particular would be worth exploring.

### **Time Factors**

One major limitation was related to the time spent factor. In reality, the values that were supposed to represent time spent actually measured the time between when the quiz was first opened and when the quiz was submitted. The Canvas quiz clock does not stop counting if students leave their computers, close the quiz, or log out of Canvas. This also raises concerns for the accuracy of the start time factor since these values were calculated by subtracting the time spent from the time of submission. While perhaps less of a concern, there is also the possibility that the time of submission does not accurately represent the time when students actually finished their assignments. There is the possibility that some students completed their assignments but waited until later to submit them in case they wanted to make changes.

To address these limitations, further research with these and other time factors could be conducted using the Canvas Quiz Log feature. While there will always be some concern regarding the accuracy of data collected through Canvas, the Canvas Quiz Log feature appears to provide more accurate and detailed time information as well as information not available from the Canvas SpeedGrader or Student Analysis report. Unfortunately, Canvas only keeps Quiz Logs for six months which limits research to ongoing or recently finished courses. Furthermore, students could also be asked to provide or record information related to these time factors to see how well students' accounts match what Canvas reports.

### **Length Factors**

No analyses were conducted to examine how the relationship between length and unit exam scores changes based on the number of assignments submitted within a unit. The average length among assignments in a unit was used to help control for differences in length among students who submitted fewer assignments. Furthermore, students who only submitted one assignment were excluded from analyses examining average length of responses in a unit and exam scores.

Additionally, the reason why greater response length leads to an increase in graded homework and unit exam scores is not clear from the results of this study. The most charitable interpretation would be that students who write more learn more. However, there are other factors that could be confounding the relationships between length of responses and homework and unit exam scores. Regarding the relationship between length of responses and exam scores, it could be the case that students who write more are more likely to use their homework responses to study for the exam. In this case, the length of students' responses would make studying for an exam easier rather than directly affecting their exam performance.

Further research will be necessary to determine how response length affects unit exam scores when the number of missing assignments within a unit are included. Rather than using averages, the total words written in a unit, regardless of how many assignments were submitted, could be used. Further research will also be necessary to parse out exactly why greater response length affects homework scores and unit exam scores. Additional information related to if and how students use their homework responses to prepare for exams should be included in future inquiries examining unit exam scores as well.

### **Specificity Factor**

For the specificity factor, there were two major limitations that will be discussed here. First, the information used for the specificity factor was likely influenced just as much by the instructors who graded the homework as the students who wrote the answers. Instructor grading preference appears to have had an impact on the types of scores students received on their homework assignments. There appeared to be a strong preference among the course's instructors for deducting -0.5 points instead of -1 points on the graded homework assignments. This tendency was prevalent enough that 6 out of 12 sections had very few to no cases where a student earned more -1 points than -0.5 points. Instructor grading fatigue could have also influenced the score an answer received. Instructors could have been less likely to pick apart a particularly long or complex answer, especially if they have been grading for a long period of time, and instead just awarded full credit if they saw the right buzzwords.

Second, the criteria used to deduct -0.5 points, -1 points, or no points at all likely varied among instructors and units. Some students could have lost points for including information in their answers that was completely unrelated to the question being asked while other students did not lose points for including superfluous information. Other students could have lost points

because they misinterpreted what a question was asking or not realized there were several parts to a question that needed to be answered. Some students could have been given passes earlier in the course for copying and pasting text directly from the instructor notes but lost points later in the course.

While the tendency to earn either primarily -0.5 points or primarily -1 points represents a fast, easy, and quantitative method for judging whether a student has a greater breadth or depth of knowledge, it may be that this method does not accurately reflect the type of knowledge students possess. This method could be replicated with a different sample that includes greater variability among the points lost on homework questions. Alternatively, a qualitative method using different criteria may be better suited for determining how the specificity in students' answers affects their grades in a course. Future researchers will need to develop a better system for measuring level of detail or breadth vs. depth of knowledge. One way of doing this could be to count the number of words and phrases associated with specificity, such as specific terms or phrases related to what is being taught, similar to the methods used by Hiller, Fisher, and Kaess (1969) and Hiller, Marcotte, and Martin (1969). Alternatively, an analysis of students' notes similar to the research conducted by Kiewra and Fletcher (1984) or Eggert (2001) may provide a better method for determining how breadth vs. depth affects students' grades.

### **Concluding Comments**

The purpose of this study was to better understand the relationships between time, length, and specificity factors found in homework on students' homework, unit exam, and final course scores. Additional research will be necessary to more fully understand how these factors affect students' grade outcomes. However, the results from this study illustrate the potential benefit of

the data available in Canvas and other LMS to instructors and other researchers and provide further justification for additional research in this area.

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## APPENDICES

## **Appendix A**

### Excel Formulas

#### **Word Count Formula in Excel**

=IF(ISBLANK(A1),"",LEN(TRIM(A1))-LEN(SUBSTITUTE(A1," ",""))+1)

#### **Alternative Mean Formula for Times of Submission and Start Times**

{=MOD(AVERAGE(A1:B2-ROUND(A1:B2,0))+1,1)}

#### **Excel Time Converter Template**

*See Excel File: Time Converter Template Example.*

## Appendix B

### Variables and Results Tables

Table B1

*Total Number of Participants After Data Cleaning*

Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
28	28	29	30	31	30	25	28	27	30	24	23

Table B2

*Mean and SD for Homework Scores for On-Time Graded Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	13.8 (1.2)	13.2 (1.8)	13.4 (1.0)	13.5 (1.0)	13.6 (1.0)	13.9 (0.9)	11.1 (2.5)	12.3 (1.4)	12.5 (1.8)	13.8 (1.5)	13.7 (1.2)	13.6 (1.1)
Unit 2	13.3 (1.1)	13.5 (1.3)	13.4 (0.9)	13.4 (1.4)	13.1 (1.3)	13.8 (1.0)	13.2 (1.3)	12.3 (1.6)	11.2 (1.6)	13.4 (1.4)	11.4 (2.6)	12.8 (1.3)
Unit 3	13.5 (1.2)	11.8 (1.9)	13.0 (0.7)	13.5 (1.1)	13.2 (1.0)	13.5 (1.4)	12.5 (1.8)	12.2 (1.4)	12.1 (1.5)	14.1 (0.9)	11.5 (1.6)	12.2 (2.2)
Unit 4	13.5 (1.4)	12.6 (2.1)	13.6 (1.1)	13.5 (1.1)	13.3 (1.1)	13.0 (1.6)	11.5 (1.7)	11.6 (1.9)	13.4 (1.4)	13.4 (1.2)	13.3 (1.4)	12.6 (1.9)
Unit 5	14.4 (0.8)	13.2 (1.8)	14.6 (0.5)	14.5 (0.5)	13.6 (1.0)	14.2 (0.7)	13.5 (1.3)	13.8 (1.0)	14.1 (0.9)	14.0 (0.6)	14.5 (0.8)	13.5 (1.1)

Table B3

*Mean and SD for Unit Exam Scores*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	42.9 (4.6)	43.5 (4.7)	42.6 (5.1)	43.1 (4.4)	42.9 (5.3)	42.7 (4.9)	40.2 (5.0)	40.5 (6.0)	38.9 (5.3)	42.1 (6.5)	42.1 (6.5)	41.4 (6.2)
Unit 2	43.1 (4.2)	42.1 (4.9)	44.0 (3.5)	44.9 (3.9)	43.2 (4.9)	43.7 (4.7)	41.9 (5.0)	41.3 (5.5)	39.6 (5.5)	43.6 (4.2)	41.5 (3.4)	42.4 (4.4)
Unit 3	41.9 (5.3)	40.4 (3.8)	41.4 (5.0)	43.4 (4.8)	42.2 (5.4)	42.0 (5.9)	40.6 (5.6)	40.6 (4.9)	38.7 (4.5)	41.8 (5.6)	40.6 (5.3)	40.6 (5.7)
Unit 4	42.8 (4.0)	41.4 (5.1)	42.9 (4.6)	43.3 (5.2)	42.2 (4.8)	42.4 (4.6)	38.9 (6.4)	41.8 (5.2)	40.1 (4.6)	41.2 (5.8)	41.0 (6.6)	40.0 (6.5)
Unit 5	45.2 (3.6)	43.8 (3.2)	43.8 (3.9)	45.2 (3.1)	44.1 (4.5)	44.2 (4.6)	41.2 (5.8)	43.0 (5.9)	44.0 (3.3)	44.1 (4.7)	43.7 (4.3)	43.9 (3.3)

Table B4

*Mean and SD for Final Percentage Scores in the Course*

Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
89.8 (5.1)	86.6 (6.8)	90.2 (4.7)	91.3 (6.3)	88.8 (6.0)	89.1 (8.0)	82.0 (8.6)	84.7 (10.6)	84.5 (7.3)	90.3 (6.6)	88.1 (8.4)	87.1 (7.0)



Table B5

*Mean and SD for Time Until the Deadline in Minutes for the On-Time Graded Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	614.6 (816.5)	569.7 (1032.9)	1102.9 (1685.4)	591.2 (768.8)	804.2 (1024.0)	473.5 (856.2)	332.4 (470.5)	669.2 (771.5)	938.4 (1578.6)	616.9 (1051.9)	173.7 (185.4)	639.8 (847.4)
Unit 2	413.9 (637.6)	193.3 (232.4)	823.3 (1685.3)	409.1 (886.9)	435.0 (573.6)	446.2 (726.8)	418.3 (628.6)	912.7 (1367.9)	534.9 (618.0)	1084.3 (1552.4)	370.7 (538.9)	1034.0 (1707.4)
Unit 3	320.8 (430.8)	277.1 (374.1)	902.2 (1367.0)	542.4 (555.3)	474.8 (744.2)	198.7 (186.1)	372.8 (450.8)	630.0 (809.4)	486.4 (1165.8)	470.0 (686.4)	387.7 (383.2)	457.4 (752.6)
Unit 4	716.7 (974.4)	350.4 (513.8)	728.7 (1518.5)	339.7 (308.3)	303.2 (394.9)	475.1 (665.6)	585.8 (862.0)	435.4 (513.4)	625.0 (1058.2)	1008.2 (1676.5)	220.2 (219.0)	553.6 (1343.9)
Unit 5	737.4 (1123.0)	263.0 (322.8)	653.5 (865.2)	459.1 (443.8)	352.3 (390.0)	536.9 (784.0)	595.1 (1112.6)	524.2 (772.5)	458.4 (533.0)	1197.5 (533.0)	412.5 (418.1)	1522.4 (2010.5)

Table B6

*Mean and SD for Time Spent in Minutes for the On-Time Graded Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	N/A	776.4 (1239.6)	N/A	1076.7 (1828.5)	N/A	530.0 (1026.8)	N/A	274.3 (512.7)	N/A	935.8 (1831.0)	N/A	677.3 (1396.6)
Unit 2	N/A	158.4 (168.4)	N/A	375.9 (720.2)	N/A	369.9 (732.2)	N/A	533.7 (953.9)	N/A	821.8 (1450.0)	N/A	377.3 (959.4)
Unit 3	N/A	259.4 (270.7)	N/A	587.5 (1223.1)	N/A	354.7 (875.9)	N/A	366.0 (1212.3)	N/A	577.1 (820.5)	N/A	432.4 (1284.7)
Unit 4	N/A	390.4 (1022.4)	N/A	416.6 (1039.4)	N/A	225.7 (348.4)	N/A	113.7 (280.2)	N/A	589.1 (1164.5)	N/A	434.9 (688.4)
Unit 5	N/A	153.9 (400.3)	N/A	275.1 (460.0)	N/A	774.5 (1585.9)	N/A	161.7 (385.3)	N/A	724.0 (1480.3)	N/A	270.0 (447.1)

Table B7

*Mean and SD in Hr for Time of Submission for the On-Time Graded Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	20:35 (5.0)	22:07 (4.9)	22:29 (6.6)	21:20 (5.5)	20:38 (4.8)	19:54 (4.5)	21:34 (3.8)	17:27 (4.5)	19:20 (3.4)	19:56 (3.3)	22:10 (2.9)	20:21 (5.8)
Unit 2	21:42 (4.1)	21:41 (3.9)	21:01 (2.9)	21:10 (3.7)	22:09 (4.8)	20:41 (4.1)	21:54 (3.5)	19:51 (5.6)	20:49 (2.5)	20:19 (3.0)	22:22 (3.5)	23:27 (5.9)
Unit 3	22:19 (4.6)	22:08 (4.2)	21:40 (5.8)	20:44 (4.9)	21:40 (4.6)	20:40 (3.0)	20:54 (4.1)	19:14 (3.3)	21:38 (3.5)	20:09 (2.5)	20:02 (4.2)	20:37 (3.0)
Unit 4	21:21 (5.6)	20:55 (3.0)	20:22 (4.0)	20:02 (3.9)	21:29 (4.8)	20:21 (4.4)	19:16 (3.2)	19:24 (4.6)	21:33 (4.1)	19:11 (4.6)	21:21 (3.7)	20:53 (4.6)
Unit 5	22:45 (6.4)	22:10 (4.5)	21:03 (6.1)	20:37 (6.0)	20:30 (4.1)	20:01 (5.1)	19:07 (3.9)	18:54 (3.4)	19:13 (3.4)	18:34 (2.9)	21:28 (5.0)	20:26 (4.9)

Table B8

*Mean and SD in Hr for Start Time for the On-Time Graded Homework Assignment*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	N/A	23:03 (7.3)	N/A	21:11 (7.2)	N/A	20:40 (7.2)	N/A	19:20 (7.3)	N/A	20:19 (6.3)	N/A	21:03 (7.4)
Unit 2	N/A	21:49 (6.0)	N/A	19:42 (5.6)	N/A	20:45 (6.3)	N/A	20:07 (6.9)	N/A	17:49 (5.4)	N/A	21:22 (6.8)
Unit 3	N/A	0:16 (7.7)	N/A	19:24 (5.9)	N/A	20:05 (5.0)	N/A	19:51 (6.2)	N/A	18:32 (5.0)	N/A	21:03 (6.3)
Unit 4	N/A	20:52 (5.5)	N/A	18:14 (5.0)	N/A	18:18 (4.8)	N/A	20:10 (6.2)	N/A	19:21 (6.6)	N/A	21:56 (7.9)
Unit 5	N/A	22:11 (5.7)	N/A	21:10 (7.9)	N/A	20:32 (7.6)	N/A	18:10 (5.0)	N/A	17:21 (4.5)	N/A	20:17 (6.3)

Table B9

*Mean and SD for Time Until the Deadline in Minutes for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	539.2 (578.4)	570.8 (634.0)	999.8 (963.5)	546.5 (659.7)	673.1 (643.0)	463.8 (557.2)	428.9 (481.6)	1156.3 (850.8)	619.1 (820.9)	570.8 (624.0)	314.8 (208.4)	647.3 (886.0)
Unit 2	437.8 (468.4)	315.7 (321.8)	594.1 (544.4)	465.9 (412.4)	566.5 (628.4)	443.3 (650.9)	487.3 (611.0)	844.6 (921.3)	583.3 (871.0)	640.1 (695.0)	356.4 (276.6)	732.8 (987.1)
Unit 3	397.4 (378.0)	391.8 (397.8)	750.6 (1245.3)	440.7 (347.5)	438.4 (403.9)	403.4 (402.7)	284.3 (290.6)	639.7 (709.8)	376.7 (551.7)	747.5 (1109.7)	280.6 (194.1)	602.4 (834.4)
Unit 4	454.0 (462.2)	252.8 (397.8)	665.4 (716.8)	514.0 (553.1)	398.0 (472.6)	445.5 (439.6)	453.0 (582.3)	690.6 (900.2)	357.4 (540.8)	613.1 (624.7)	367.5 (306.7)	599.0 (843.3)
Unit 5	658.8 (873.1)	368.1 (421.3)	912.4 (831.3)	495.8 (359.3)	576.9 (554.0)	586.3 (622.1)	539.7 (832.8)	1053.1 (1407.1)	514.0 (654.3)	735.8 (847.5)	361.2 (276.1)	879.9 (1107.9)

Table B10

*Mean and SD for Time Spent in Minutes for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	N/A	474.2 (638.7)	N/A	714.5 (902.6)	N/A	581.5 (566.8)	N/A	475.3 (674.7)	N/A	928.6 (1032.3)	N/A	494.1 (452.8)
Unit 2	N/A	259.7 (263.6)	N/A	420.8 (474.4)	N/A	343.3 (395.1)	N/A	372.8 (537.0)	N/A	638.5 (727.9)	N/A	252.3 (314.9)
Unit 3	N/A	276.2 (410.8)	N/A	500.2 (598.6)	N/A	293.0 (326.8)	N/A	328.1 (667.2)	N/A	616.8 (758.5)	N/A	362.1 (546.4)
Unit 4	N/A	309.1 (493.9)	N/A	366.8 (506.3)	N/A	313.4 (439.6)	N/A	305.1 (563.4)	N/A	668.3 (862.9)	N/A	482.1 (568.7)
Unit 5	N/A	224.7 (378.8)	N/A	351.0 (369.6)	N/A	431.1 (623.2)	N/A	257.2 (424.6)	N/A	496.5 (549.7)	N/A	333.7 (359.6)

Table B11

*Mean and SD in Hr. for Time of Submission for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	20:20 (2.8)	20:24 (3.9)	21:30 (4.5)	20:15 (2.9)	20:09 (2.8)	19:36 (3.0)	20:03 (2.6)	18:56 (3.2)	19:37 (2.8)	19:28 (2.8)	20:40 (2.6)	19:22 (3.2)
Unit 2	20:58 (3.9)	21:17 (3.0)	20:09 (4.0)	19:39 (2.8)	19:37 (2.8)	20:40 (2.8)	20:50 (2.6)	18:35 (2.8)	21:03 (2.2)	20:27 (2.6)	20:07 (2.3)	20:25 (3.4)
Unit 3	20:26 (3.4)	20:39 (3.0)	20:32 (3.3)	19:26 (3.0)	20:01 (2.8)	20:08 (3.0)	20:41 (2.4)	19:30 (2.5)	20:47 (2.0)	20:54 (2.3)	19:55 (2.5)	19:54 (2.8)
Unit 4	20:29 (4.0)	20:38 (2.9)	20:02 (4.3)	19:21 (2.9)	20:27 (3.7)	19:49 (3.0)	20:15 (2.7)	18:48 (3.0)	20:59 (2.2)	20:04 (3.9)	20:27 (3.7)	20:18 (3.2)
Unit 5	20:30 (4.4)	20:38 (3.0)	20:27 (5.5)	18:20 (3.2)	20:21 (3.3)	19:21 (3.2)	19:46 (3.3)	19:16 (2.6)	19:56 (2.4)	19:20 (1.9)	20:01 (3.9)	19:55 (3.3)

Table B12

*Mean and SD in Hr for Start Time for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	N/A	19:44 (5.7)	N/A	17:39 (4.3)	N/A	18:05 (5.6)	N/A	17:04 (4.3)	N/A	18:50 (6.0)	N/A	18:05 (4.8)
Unit 2	N/A	18:38 (4.7)	N/A	16:53 (2.7)	N/A	18:59 (5.1)	N/A	17:04 (3.1)	N/A	16:44 (3.0)	N/A	19:46 (5.9)
Unit 3	N/A	20:18 (6.0)	N/A	17:45 (4.5)	N/A	17:38 (2.8)	N/A	17:55 (4.5)	N/A	17:57 (4.2)	N/A	17:58 (2.8)
Unit 4	N/A	19:46 (4.6)	N/A	18:26 (5.5)	N/A	17:41 (4.2)	N/A	17:31 (4.6)	N/A	18:28 (6.0)	N/A	19:22 (5.9)
Unit 5	N/A	20:34 (5.2)	N/A	20:41 (7.4)	N/A	17:45 (4.9)	N/A	17:20 (2.6)	N/A	16:51 (2.9)	N/A	18:16 (4.5)

Table B13

*Mean and SD for Consistency Values for Time Until the Deadline in Minutes for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	455.3 (561.2)	401.7 (527.5)	884.6 (942.2)	375.3 (478.8)	505.1 (432.3)	344.0 (591.5)	358.9 (496.4)	1074.2 (652.0)	505.7 (771.7)	429.6 (505.4)	285.7 (258.4)	426.6 (631.7)
Unit 2	344.7 (399.8)	288.5 (345.8)	539.0 (486.7)	480.2 (639.7)	502.1 (534.5)	338.1 (491.5)	541.3 (734.6)	579.0 (652.8)	432.1 (612.0)	529.8 (662.1)	308.8 (291.0)	563.1 (677.0)
Unit 3	390.6 (505.8)	419.7 (497.1)	436.2 (494.5)	322.7 (343.0)	397.2 (441.2)	325.0 (470.0)	197.7 (255.4)	453.4 (522.1)	317.5 (568.2)	657.5 (1101.2)	207.9 (208.1)	346.7 (440.6)
Unit 4	317.2 (405.7)	162.9 (239.8)	622.2 (811.7)	406.5 (415.6)	287.7 (523.6)	347.3 (439.6)	366.8 (455.0)	471.2 (591.3)	328.9 (464.4)	552.8 (759.0)	298.6 (351.4)	521.2 (831.6)
Unit 5	519.9 (727.3)	319.4 (478.0)	893.8 (834.4)	314.7 (292.8)	461.8 (593.6)	549.0 (669.9)	348.5 (459.9)	652.2 (823.5)	469.4 (716.4)	659.8 (894.9)	195.4 (189.0)	556.6 (633.4)

Table B14

*Mean and SD for Consistency Values for Time Spent in Minutes for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	N/A	531.2 (783.4)	N/A	727.2 (871.0)	N/A	529.6 (645.6)	N/A	547.7 (803.5)	N/A	910.6 (996.6)	N/A	513.5 (640.1)
Unit 2	N/A	192.7 (282.1)	N/A	414.6 (581.3)	N/A	277.6 (461.7)	N/A	380.3 (587.0)	N/A	532.3 (578.1)	N/A	275.7 (501.8)
Unit 3	N/A	244.8 (514.8)	N/A	531.7 (782.6)	N/A	328.6 (493.0)	N/A	333.1 (798.8)	N/A	516.2 (629.9)	N/A	343.8 (532.3)
Unit 4	N/A	341.9 (704.0)	N/A	330.9 (468.8)	N/A	327.0 (637.8)	N/A	356.2 (806.8)	N/A	617.8 (957.8)	N/A	519.3 (784.9)
Unit 5	N/A	282.4 (621.3)	N/A	333.3 (390.5)	N/A	476.6 (805.9)	N/A	187.2 (278.1)	N/A	490.5 (617.0)	N/A	372.4 (440.0)

Table B15

*Mean and SD for Consistency Values for Time of Submission for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	153.5 (108.3)	141.9 (112.3)	127.9 (97.6)	133.7 (100.8)	153.7 (90.0)	129.9 (93.1)	120.7 (72.4)	169.3 (96.7)	127.6 (76.7)	156.2 (90.5)	134.3 (96.2)	107.5 (75.6)
Unit 2	117.0 (90.3)	139.7 (116.4)	172.9 (96.4)	127.3 (66.4)	149.8 (90.1)	103.8 (83.3)	107.0 (90.1)	130.9 (79.2)	116.5 (101.0)	135.5 (86.3)	124.9 (71.4)	135.5 (107.6)
Unit 3	141.5 (97.6)	121.4 (116.2)	142.0 (112.7)	116.7 (81.3)	157.8 (94.3)	123.2 (107.0)	113.7 (82.5)	128.8 (77.6)	129.6 (85.1)	108.7 (96.5)	135.6 (80.7)	128.9 (97.0)
Unit 4	150.7 (106.4)	93.6 (83.7)	137.8 (95.0)	147.9 (79.6)	134.7 (75.7)	128.4 (90.9)	135.9 (93.7)	155.6 (90.3)	137.4 (88.8)	149.0 (95.8)	144.7 (68.8)	111.5 (94.6)
Unit 5	118.0 (90.1)	124.7 (105.3)	166.9 (81.3)	184.9 (102.8)	148.9 (84.2)	149.7 (101.1)	91.4 (79.8)	143.8 (82.0)	137.1 (87.4)	132.5 (65.6)	133.1 (109.1)	148.4 (108.2)

Table B16

*Mean and SD for Consistency Values for Start Time for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	N/A	172.3 (117.2)	N/A	201.0 (97.3)	N/A	176.5 (82.3)	N/A	183.7 (79.7)	N/A	168.4 (95.1)	N/A	182.2 (100.3)
Unit 2	N/A	150.4 (114.5)	N/A	155.1 (77.6)	N/A	142.9 (92.6)	N/A	142.1 (92.0)	N/A	165.5 (96.9)	N/A	140.0 (73.4)
Unit 3	N/A	155.8 (120.9)	N/A	140.9 (99.4)	N/A	167.6 (95.3)	N/A	120.5 (68.1)	N/A	129.8 (75.1)	N/A	152.4 (85.6)
Unit 4	N/A	147.5 (114.3)	N/A	185.5 (98.3)	N/A	152.5 (80.2)	N/A	145.4 (75.4)	N/A	155.8 (75.2)	N/A	125.9 (77.7)
Unit 5	N/A	147.6 (104.3)	N/A	204.3 (115.2)	N/A	150.2 (88.8)	N/A	131.5 (75.9)	N/A	138.1 (89.6)	N/A	177.3 (95.1)

Table B17

*Mean and SD for Words per Question for the On-Time Graded Homework Submission*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	50.8 (18.0)	43.1 (17.2)	39.1 (12.7)	51.4 (23.1)	45.2 (15.4)	47.9 (17.4)	45.9 (12.3)	37.1 (10.7)	44.5 (16.4)	48.4 (16.0)	35.7 (10.7)	42.1 (16.0)
Unit 2	45.7 (19.0)	34.4 (16.5)	41.3 (16.2)	49.5 (24.2)	45.4 (18.6)	49.7 (14.4)	51.0 (17.0)	38.9 (12.5)	38.0 (12.0)	49.8 (16.1)	38.7 (12.9)	45.0 (13.8)
Unit 3	51.3 (17.5)	36.7 (14.8)	48.6 (15.8)	47.2 (22.0)	55.8 (22.4)	45.3 (16.3)	44.6 (16.7)	47.4 (13.7)	43.5 (18.7)	40.8 (13.6)	40.7 (14.0)	40.4 (15.4)
Unit 4	48.0 (20.1)	37.8 (12.8)	48.5 (11.4)	59.0 (33.2)	50.3 (16.2)	43.1 (13.4)	49.6 (22.5)	43.6 (14.5)	41.8 (14.8)	43.4 (12.9)	49.6 (13.9)	53.4 (21.7)
Unit 5	38.7 (14.2)	28.1 (8.6)	36.2 (10.8)	41.2 (23.3)	45.6 (15.9)	40.2 (12.9)	52.5 (29.0)	42.8 (14.8)	33.8 (12.4)	37.8 (10.4)	32.7 (15.1)	33.2 (9.9)

Table B18

*Mean and SD for Words per Question for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	44.5 (13.7)	34.5 (15.7)	40.2 (12.9)	49.5 (19.7)	45.1 (13.9)	48.0 (15.3)	45.6 (10.0)	38.2 (11.1)	40.2 (13.1)	46.7 (11.9)	38.3 (9.9)	44.8 (13.9)
Unit 2	45.5 (18.9)	36.7 (15.8)	40.9 (12.3)	48.0 (24.5)	45.8 (17.5)	44.2 (14.1)	49.8 (16.5)	36.9 (11.0)	39.9 (14.1)	44.7 (12.4)	38.3 (9.4)	41.9 (11.9)
Unit 3	53.7 (19.7)	36.6 (13.7)	49.0 (15.5)	47.1 (23.6)	52.4 (18.6)	43.2 (15.2)	47.0 (16.4)	42.2 (13.8)	46.2 (16.9)	45.4 (13.8)	42.7 (14.5)	40.0 (13.2)
Unit 4	51.1 (20.3)	39.5 (13.0)	47.1 (11.8)	51.5 (26.3)	49.0 (16.1)	46.5 (13.1)	50.3 (21.0)	44.0 (14.5)	42.5 (15.2)	47.1 (13.9)	44.2 (14.0)	44.5 (13.5)
Unit 5	39.1 (15.2)	31.8 (10.3)	40.1 (9.7)	45.1 (24.1)	40.6 (14.6)	37.5 (10.6)	47.5 (24.7)	42.5 (14.6)	36.6 (12.2)	38.7 (10.9)	36.7 (15.5)	34.4 (8.9)

Table B19

*Mean and SD for Consistency Values for Words per Question for The Graded Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	19.5 (8.2)	15.3 (6.0)	15.9 (6.9)	18.7 (8.9)	17.4 (6.7)	19.0 (8.2)	17.3 (7.1)	15.4 (5.8)	13.5 (3.4)	20.7 (8.9)	15.0 (5.1)	20.0 (8.8)
Unit 2	16.9 (6.6)	12.8 (5.1)	13.9 (4.8)	18.6 (7.2)	15.9 (5.4)	17.8 (6.9)	19.4 (9.4)	13.8 (4.9)	11.9 (2.9)	17.9 (6.4)	15.1 (6.0)	17.7 (6.4)
Unit 3	25.3 (11.2)	14.4 (5.6)	23.1 (10.1)	17.3 (6.3)	28.6 (11.3)	18.2 (8.1)	17.0 (4.6)	17.6 (5.9)	16.3 (7.7)	19.8 (9.9)	21.3 (13.1)	15.7 (6.4)
Unit 4	17.9 (7.3)	14.4 (4.9)	17.8 (5.6)	21.5 (9.7)	17.1 (6.0)	16.5 (5.6)	20.0 (13.9)	19.3 (7.3)	13.0 (4.3)	17.0 (7.7)	24.0 (7.0)	27.0 (13.8)
Unit 5	19.1 (6.2)	10.7 (3.6)	13.0 (4.4)	13.4 (6.7)	19.6 (7.8)	18.2 (6.5)	18.6 (7.8)	18.0 (6.1)	11.8 (4.3)	17.2 (5.0)	13.0 (5.1)	14.6 (4.4)

Table B20

*Mean and SD for Consistency Values for Words per Question for All On-Time Homework Assignments*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
Unit 1	7.8 (4.0)	7.2 (4.3)	6.6 (3.3)	7.3 (3.8)	7.3 (3.7)	8.5 (3.7)	7.6 (5.0)	5.4 (2.8)	6.2 (3.9)	7.4 (3.7)	5.8 (2.4)	9.5 (8.3)
Unit 2	6.8 (4.0)	6.7 (4.0)	7.2 (4.8)	6.2 (3.4)	6.4 (3.6)	6.5 (3.0)	6.8 (4.5)	5.0 (2.4)	5.6 (3.8)	6.8 (2.9)	6.3 (3.8)	7.2 (3.5)
Unit 3	10.1 (6.7)	6.5 (4.4)	9.1 (7.3)	6.7 (4.1)	7.9 (3.1)	6.5 (3.2)	7.7 (5.2)	6.8 (4.0)	7.7 (5.6)	6.1 (3.1)	9.1 (7.1)	7.0 (3.5)
Unit 4	6.7 (3.1)	6.2 (4.3)	6.4 (3.3)	8.0 (4.7)	7.3 (5.2)	7.3 (4.4)	8.2 (6.7)	6.6 (4.6)	6.1 (3.5)	6.8 (4.6)	7.6 (5.5)	10.4 (10.6)
Unit 5	6.6 (3.3)	5.2 (2.6)	6.1 (2.7)	5.6 (2.8)	6.8 (3.7)	5.4 (2.4)	6.9 (3.6)	6.1 (4.4)	5.7 (4.0)	5.4 (2.6)	7.0 (3.2)	5.2 (2.3)



Table B21

*Distribution of Students who Earned Mostly -0.5 Points or -1 Points for the Fall 2018 Semester*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	-0.5	-1.0	-0.5	-1.0	-0.5	-1.0	-0.5	-1.0	-0.5	-1.0	-0.5	-1.0
Unit 1	22.0	0.0	25.0	0.0	29.0	0.0	20.0	3.0	19.0	3.0	11.0	4.0
Unit 2	23.0	0.0	26.0	0.0	30.0	0.0	17.0	0.0	3.0	18.0	6.0	10.0
Unit 3	19.0	2.0	27.0	0.0	30.0	0.0	20.0	2.0	15.0	4.0	5.0	13.0
Unit 4	16.0	1.0	25.0	0.0	26.0	0.0	18.0	0.0	21.0	1.0	16.0	3.0
Unit 5	15.0	1.0	15.0	0.0	28.0	0.0	18.0	0.0	11.0	4.0	8.0	3.0

Table B22

*Distribution of Students who Earned Mostly -0.5 Points or -1 Points for the Fall 2019 Semester*

	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
	-0.5	-1.0	-0.5	-1.0	-0.5	-1.0	-0.5	-1.0	-0.5	-1.0	-0.5	-1.0
Unit 1	22.0	0.0	28.0	0.0	24.0	0.0	17.0	5.0	8.0	6.0	13.0	3.0
Unit 2	16.0	4.0	26.0	0.0	26.0	2.0	25.0	0.0	19.0	4.0	17.0	2.0
Unit 3	16.0	8.0	27.0	0.0	25.0	0.0	24.0	0.0	12.0	5.0	6.0	9.0
Unit 4	23.0	1.0	25.0	0.0	25.0	0.0	24.0	0.0	24.0	2.0	10.0	8.0
Unit 5	12.0	10.0	17.0	0.0	23.0	0.0	20.0	0.0	21.0	2.0	17.0	1.0

Table B23

*Mean and SD for Specificity Scores*

Section 1		Section 2		Section 3		Section 4		Section 5		Section 6	
Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019	Fall 2018	Fall 2019
0.04 (0.11)	0.18 (0.19)	0.0 (0.00)	0.0 (0.0)	0.0 (0.00)	0.02 (0.06)	0.08 (0.16)	0.04 (0.10)	0.31 (0.24)	0.17 (0.19)	0.45 (0.31)	0.25 (0.18)

Table B24

*Results of the Simple Effect Analyses for Significant Interaction Effects with Unit*

	Unit 1 Est. Value	Unit 2 Est. Value	Unit 3 Est. Value	Unit 4 Est. Value	Unit 5 Est. Value
Time Spent, up to 2 Hr, for the On-Time Graded Homework Assignments	-0.0077 (0.0047)	0.0029 (0.0051)	0.0116* (0.0051)	0.0079 (0.0058)	-0.0002 (0.0041)
Time Until the Deadline Consistency in Minutes for all On-Time Homework Assignments	-0.0003 (0.0003)	0.0008* (0.0003)	-9.83X10 <sup>-5</sup> (0.0004)	-9.27X10 <sup>-5</sup> (0.0004)	0.0006* (0.0003)
Words Per Question for the On-Time Graded Homework Assignments	0.0398*** (0.0047)	0.0428*** (0.0043)	0.0434*** (0.0047)	0.0438*** (0.0040)	0.0219*** (0.0032)
Response Length Consistency for the On-Time Graded Homework Assignments	0.0345** (0.0099)	0.0618*** (0.0112)	0.0170* (0.0076)	0.0231** (0.0081)	0.0121 (0.0082)

\* =  $p$ -value  $\leq 0.05$

\*\* =  $p$ -value  $\leq 0.01$

\*\*\* =  $p$ -value  $\leq 0.001$

Table B25

*Additional Words Written per Assignment and Additional Total Words Written Needed to Equal a 1-Point Increase on the Graded Homework Score.*

	Estimated Value	Additional Words per Question	Additional Total Words
Unit 1	0.0398	25.1	377
Unit 2	0.0428	23.4	351
Unit 3	0.0434	23.0	346
Unit 4	0.0438	22.8	343
Unit 5	0.0219	45.7	685

Table B26

*Additional Words Written per Assignment and Additional Total Words Written Needed to Equal a 1-Point Increase on the Unit Exam Score Depending on Number of Assignments Submitted.*

	Estimated Value	Additional Words per Assignment	Additional Total Words
4 Assignments	0.069	217.5	870
3 Assignments	0.069	217.5	653
2 Assignments	0.069	217.5	435

Table B27

*Additional Response Length Standard Deviation (Consistency) Values Needed to Equal a 1-Point Increase on the Graded Homework Assignment*

	Estimated Value	Additional Increase in SD (Consistency) Value
Unit 1	0.0345**	29.0
Unit 2	0.0618***	16.2
Unit 3	0.0170*	58.8
Unit 4	0.0231**	43.3
Unit 5	0.0121	82.6

\* =  $p$ -value  $\leq 0.05$

\*\* =  $p$ -value  $\leq 0.01$

\*\*\* =  $p$ -value  $\leq 0.001$

## VITA

Alexander Cody Price was born in Knoxville, Tennessee. He spent his childhood and adolescence in Maryville, Tennessee. He obtained his B.S. with a double major in Psychology and Philosophy at David Lipscomb University in the fall of 2016. Starting in the fall of 2017, Alexander attended the University of Tennessee's School Psychology Ph.D. Program. In December of 2019, he earned his Master of Science degree in Teacher Education with a concentration in Applied Behavior Analysis. Alexander will receive his Ph.D. in August of 2022 upon completion of a year-long pre-doctoral internship with the Tennessee Internship Consortium in Knoxville, Tennessee.