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Time Is On My Side . . . Or Is It?: Time of Day and Achievement in Asynchronous Learning Environments

Angela Gilleland

ACCEPTANCE

This dissertation, TIME IS ON MY SIDE. . . OR IS IT?: TIME OF DAY AND ACHIEVEMENT IN ASYNCHRONOUS LEARNING ENVIRONMENTS, by ANGELA H. GILLELAND, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education and Human Development, Georgia State University.

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TIME IS ON MY SIDE….OR IS IT?; TIME OF DAY AND ACHIEVEMENT IN ASYNCHRONOUS LEARNING ENVIRONMENTS

by

ANGELA H GILLELAND

Under the Direction of Stephen Harmon, Ph.D.

ABSTRACT

Previous research suggests that the optimal time of day (TOD) for cognitive function for young adults occurs in the afternoon and evening times (Allen, et al. 2008; May, et al. 1993). The implication is college students may be more successful if they schedule classes and tests in the afternoon and evening times, but in asynchronous learning environments, "class" and tests take place at any TOD (or night) a student might choose. The problem is that there may be a disadvantage for students choosing to take tests at certain TOD. As educators, we need to be aware of potential barriers to student success and be prepared to offer guidance to students.

This research study found a significant negative correlation between TOD and assessment scores on tests taken between 16:01 and 22:00 hours as measured in military time. While this study shows that academic performance on asynchronous assessments was high at 16:00 hours, student performance diminished significantly by 22:00 hours. When efforts were taken to

mitigate the extraneous variables related to test complexity and individual academic achievement, the effect TOD had on assessment achievement during this time period was comparable to the effect of test complexity on that achievement. However, when analyzed using a small subset of the data neither GPA nor TOD could be used to predict student scores on tests taken between 16:01 and 22:00 hours. Finally, individual circadian arousal types (evening, morning and neutral) (Horne & Ostberg, 1976) and actual TOD students took tests were analyzed to determine if synchrony, the match between circadian arousal type and peak cognitive performance, existed. The synchrony effect could not be confirmed among morning type students taking this asynchronous online course, but evidence suggests that synchrony could have contributed to student success for evening types taking this asynchronous online courses.

The implication of this study is that online instructors, instructional designers and students should consider TOD as a factor affecting achievement in asynchronous online courses. Results of this research are intended to propose further research into TOD effects in asynchronous online settings, and to offer guidance to online students as well as online instructors and instructional designers faced with setting deadlines and advising students on how to be successful when learning online.

INDEX WORDS: Time of day, TOD, Asynchronous learning environments, Online learning, Assessments, Circadian arousal type, Synchrony, Learning analytics

TIME IS ON MY SIDE….OR IS IT?: TIME OF DAY AND ACHIEVEMENT IN ASYNCHRONOUS LEARNING ENVIRONMENTS

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DEDICATION

This work is dedicated to my loving family, and to online students everywhere.

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Abbreviations

CPT	Connors Continuous Performance Test
EA	Explicit Application
FLE	Flexible Learning Environment
GPA	Grade point average
IA	Implicit Application
LMS	Learning Management System
MEQ	Morning Eveningness Questionnaire (Horne & Ostberg, 1976)
RU	Recognition and understanding
TOD	Time of day
TUCE-4	The Test of Understanding of College Economics, 4th Edition (Walstad & Rebeck, 2008).
WAIS	Weschler Adult Intelligence Scale

1 THE PROBLEM

Introduction

One draw of online learning is convenience. Students and instructors enjoy the flexibility offered by asynchronous online courses, which allow them to learn where and when it is convenient for them (Tallent-Runnels, et al., 2006). Because multiple-choice (including true/false) assessment items can be scored automatically by the Learning Management System (LMS) (Oosterhof, et al., 2008) many online instructors use these questions to assess learning outcomes. In addition, multiple-choice test items are well suited for asynchronous online instruction because they can be time sensitive (Whitrock & Baker, 1991) which helps ensure the security and integrity of testing (Oosterhof, et al., 2008). Multiple-choice questions can measure both ability to recall as well as higher level cognitive skills such as classification, application, discrimination, analysis and evaluation (Hancock, 1994; Oosterhof, et al., 2008). LMSs allow instructors to set deadlines for tests to be taken asynchronously, and thus it may be assumed that students take the test within the date range specified no matter the time of day chosen. Students could hypothetically take the test at one o'clock in the morning if they so choose, but does the time of day (TOD) students choose to take tests affect their performance?

Problem Statement

Previous research suggests that the optimal TOD for cognitive function (such as that utilized when taking multiple-choice tests) for young adults occurs in the afternoon and evening times (Allen, et al. 2008; May, et al. 1993). The implication is that college students may be more successful if they schedule classes and tests in the afternoon and evening times, but in asynchronous learning environments "class" and tests take place at any TOD (or night) a student might

choose. The problem is that TOD may be a factor affecting student achievement in asynchronous learning environments. As educators, we need to be aware of potential barriers to student success such as TOD for test taking and be prepared to offer guidance to students on how and when to take tests.

Purpose

The purpose of this study is to determine if a relationship exists between TOD and achievement on assessments in an asynchronous learning environment. The study also examines the role of circadian arousal type, the degree of alertness people exhibit in the morning versus the evening (Horne & Ostberg, 1976), and TOD to determine if synchrony, the link between peak cognitive performance and peak circadian arousal (May & Hasher, 1998), existed for undergraduate students taking an asynchronous online course.

Rationale

A recent survey of online educators in the United States revealed that 70.8% of academic leaders reported online learning is critical to their institution's long-term educational strategy (Allen & Seaman, 2014). Since the early 2000's, U.S. institutions of higher education have steadily increased the number of online courses offered (Allen & Seaman, 2014). Clearly there is an emphasis on online learning in America's higher education system, but despite this, there is little agreement within the research as to the effectiveness of online education versus learning in a traditional setting (Allen, et al., 2002; Anstine & Skidmore, 2005; Bergstrand & Savage, 2013; Botsch & Botsch, 2012; Clark, 1983; Coates, et al., 2004; Farinella, 2007; Lee & Choi, 2011; Nguyen, 2015; Russell, 1999).

Nguyen (2015) wrote a meta-analysis on the research examining the effectiveness of online learning which spotlights the discrepancies within this body of literature by categorizing findings as positive, negative, mixed and null. For example, some of the positive research findings indicate that students experienced improved learning outcomes, higher test scores and increased engagement as a result of online education (Nguyen, 2015). On the other hand, Nguyen (2015) cites numerous studies that found lower test scores, lower engagement and lower satisfaction among students taking online courses. Nguyen also discusses research which he categorizes as mixed and null findings. These studies found a mixture of positive effects and negative effects of online education, or they found no difference between learning outcomes for online versus face-to-face delivery. The wide range of discrepant research findings on the effectiveness of online learning indicates a need for more research on the factors. Since student success is one measure of effectiveness for online learning, it is important to explore the factors that contribute to student success.

The subject of retention in online classes is another area where the research is contradictory. Many researchers join 44.6% of academic leaders who see retention as a greater problem in online courses than in traditional courses (Allen & Seaman, 2014). Lee and Choi (2011) wrote a systematic meta-analysis of literature from 1999-2009 related to the issue of online course dropout rates. From research examined for this meta-analysis, 44 factors contributing to student dropout rates for online courses were identified. These fit into three categories; student factors, course/program factors, and environmental factors, with student factors most frequently mentioned in the articles. The student factors cited were academic background, relevant experiences, skills, and psychological attributes (i.e.: motivation and self-efficacy). Botsch and Botsch (2012) cite a higher demand for online courses among undergraduate students, and Lee and Choi

(2011) cite a rise in online course enrollment. However, Lee and Choi also show data revealing a higher dropout rate for online courses versus traditional courses.

Forecasts indicate that online course offerings will continue to grow within American institutions of higher education (Allen & Seaman, 2014). Therefore it is important to identify factors contributing to student success and failure when learning online so that educators can, when possible, learn from them and mitigate issues that might prevent student success. TOD could be one factor affecting student success with online learning, and while there are bodies of research that could support recommendations for students on optimal TOD selection for online learning, none of those studies specifically target online learners in asynchronous settings.

There is a great deal of research on TOD effects on cognitive ability (Allen, et al., 2008; Anderson, et al., 1991; Bennett, et al., 2008; Borella, 2011; Coloquhoun, 1971; Folkard, 1982; Hasher, et al., 2002; Intons-Peterson, et al., 1998; Li, et al., 1998; Manly, et al., 2002; May, 1999; May et al., 1993; May & Hasher, 1998). The vast majority of studies on TOD effects relate to aging and compare the cognitive ability of young adults to that of older adults. For example, Borella (2011) tested groups of young adults (aged 20-28) and older adults (aged 60-78) on cognitive skills during morning times versus evening times; this basic research design is typical for the bulk of the literature on TOD and aging. The present study focused on TOD effects within the context of undergraduate education which is primarily composed of students who fall into the young adult category. While this design built on TOD research related to aging, the results are directly applicable to undergraduate college students.

Previous research on TOD has largely been done with subjects in a face-to-face environment (Allen, et al., 2008; Anderson, et al., 1991; Bennett, et al., 2008; Callan, 1999; Coloquhoun, 1971; Folkard, 1982; Intons-Peterson, et al., 1998; Li, et al., 1998; May, 1999; May et

al., 1993; May & Hasher, 1998). Testing participants in a clinical environment is a good way to increase internal validity because extraneous environmental factors are controlled. For example, Li's (1998) research on synchrony, tested the effects of TOD on the length of time it took subjects to read passages and on their reading comprehension. Participants were presented with letter-sized pages of reading material, and comprehension tests were administered orally. Other studies used computers to administer the tests, but experiments were conducted in a laboratory setting (Borella, et al., 2011; Hasher, et al., 2002; Manly, et al., 2002). For example, Hasher's (2002) study on the TOD effects on distractibility and interference presented word lists and distractors on a computer screen, then asked participants to orally recite words from this list that could be recalled. Viewing the demonstration of cognitive function within a clinical setting as a constant that is transferrable to the natural learning environment is problematic as it fails to consider all of the extraneous factors which cannot be controlled in that student's natural environment. While testing TOD effects in the natural environment may risk internal validity, when a large sample size is used, external validity is expanded because extraneous factors are a reality in the natural learning environments; especially for students taking asynchronous online courses. This study did not require participants to report to a laboratory setting but instead gathered data generated from students' natural environments within which they normally participate in their online course. When students take online courses, they have the freedom to complete assignments and tests in any environment they choose. These environments may or may not be conducive to learning and present an array of confounding variables not present in a laboratory setting. Gathering data from students in their natural learning environments provides a more realistic example of student performance with distractions and other variables at play. No effort was taken

to control for extraneous environmental factors. Thus, findings of this study provide information on student behavior and performance in real-world asynchronous online settings.

Earlier studies tested students' cognitive ability using abstract cognitive reasoning assessments (Allen, et al., 2008; Anderson, et al., 1991; Bennett, et al., 2008; Borella, 2011; Colo-quhoun, 1971; Folkard, 1982; Hasher, et al., 2002; Intons-Peterson, et al., 1998; Li, et al., 1998; Manly, et al., 2002; May, 1999; May et al., 1993; May & Hasher, 1998). For example, Bennett, et al. (2008) used the vocabulary subset of the Weschler Adult Intelligence Scale (WAIS) to assess verbal ability. The WAIS requires participants to provide verbal definitions to random words which increase in difficulty as the test progresses (Bennett, et al., 2008). Bennett's study also used the Connors Continuous Performance Test (CPT) to assess letter recognition. In this test, computers were used to present participants with sets of ten letters, each containing the letter X. Participants were then instructed to perform a key press for all letters except X, for which they were told to withhold response (Bennett, et al., 2008) Both the WAIS and the CPT are tests of cognitive reasoning, but they are abstract in that they involve tasks apart from any specific task that participants would perform in the context of everyday life (academic endeavors included). Contrastingly, this study uses academic performance on subject matter-related tests to investigate TOD effects on cognitive ability. This measure may yield results more generalizable to student performance in other courses and may therefore be preferable to tests of abstract cognitive reasoning. This study represents an important addition to existing research on TOD because there is little prior research on TOD effects in academic settings using academic measures and these studies are in face to face settings. Further, to my knowledge this is the first study to investigate the effects of TOD on achievement in online learning environments.

Finally, experimental research on the effects of TOD on achievement have used assessments administered at specific times of the day and night. For example, Allen, et al. (2008) tested students between 8 AM - 10 AM, 12 PM - 2 PM, and 6 PM - 8 PM, and found that college students performed better at cognitive tasks during the afternoon and evening time periods. The present study examines achievement on academic tests which include submissions between 12:00 AM (00:00) and11:59 PM (23:59). The span of time included in these samples is unprecedented. Here again, this study investigates TOD effects within the student's natural learning environment. TOD is an environmental factor that is not controlled in an asynchronous online learning environment, therefore it is not controlled in this study.

Investigating the impact of TOD on achievement in online learning environments is important for determining if students taking tests at certain times of day are at a disadvantage. In addition to providing valuable information to students, findings of this study also offer guidance to online instructors and instructional designers faced with setting deadlines and advising students on how to be successful when learning online. This study is also intended as a call for further quantitative research into TOD effects on achievement in asynchronous settings. Results may also serve as a foundation of common experiences for future qualitative research on individual experiences with online learning and TOD taking human and specific environmental issues into consideration.

Research Questions

1. What is the relationship between TOD and academic achievement on multiple-choice assessments within an asynchronous online course?

a. What achievement patterns can be found in the TOD students in asynchronous online classes choose to take tests?
b. What is the degree of the relationship between TOD and achievement within those achievement patterns?
c. Are TOD effects different depending on the level of cognitive ability being measured by the multiple choice test?
d. After controlling for individual differences in overall academic achievement using GPA, does TOD predict scores on assessments in an asynchronous learning environment?

2. What role do circadian arousal types play in the relationship between TOD and achievement on assessments in an asynchronous learning environment?

Expectations and Limitations

Based on the literature related to TOD and young adults/college students, I expected to see a curvilinear relationship between test scores and TOD with higher scores for tests taken in the afternoon and early evening hours (Allen, et al., 2008; May, 1999). One particular point of interest involved the results of the Morningness Eveningness Questionnaire (MEQ) (Horne & Ostberg, 1976). This questionnaire is a well-established instrument that classifies individuals according to circadian arousal patterns as evening types, neutral types, or morning types based on score. Based on evidence shown within the TOD literature, I expected to find the synchrony effect; the match between circadian arousal type and peak cognitive performance (May & Hasher, 1998).

While it was impossible to control for all extraneous variables that contribute to achievement on tests, the cognitive ability being measured by each assessment was considered to determine the impact on TOD effect. In addition, effort to control for overall individual academic achievement was taken through statistically controlling for each student's overall grade point average (GPA). One limitation to the GPA data is that it was self-reported, but since accessing GPA data violated FERPA laws, this limitation could not be avoided.

While these results do not provide the opportunity to unequivocally state that TOD selection affects achievement by a certain amount, they will help to formulate and reinforce recommended guidelines for students when selecting the TOD to take assessments for online courses. In addition, these results are not meant to represent over-arching truths. Individual differences among learners is assumed within this study, therefore results should be translated to recommendations versus mandates. I do not advocate program control over the time students choose to take tests, instead students should be provided with guidelines on TOD selection, and the choice to follow guidelines should be left up to them.

Overview of the Study Methods

The intent of this study was to determine if a relationship existed between TOD and assessment achievement in an asynchronous learning environment. The study also sought to determine whether synchrony between students' peak circadian arousal period and peak academic performance existed among students taking an asynchronous online course. This analysis was conducted on data obtained from students taking an undergraduate online course, "Principles of Microeconomics" (Econ 2106), during the fall 2015 semester at a large southeastern U.S. Uni-

versity. This course was delivered through an LMS that automatically records the TOD an assessment is taken, and scores the test. SPSS was used to examine quantitative data taken directly from the LMS in addition to data gathered from students through a survey.

The study was conducted in two parts. The first part of this study analyzed a large data set consisting of scores and times from 84 students on 10 tests administered throughout the fall 2015 semester. The first part of the study also involved analysis of test items to determine the cognitive complexity for each question, which was then used to determine overall cognitive complexity for each test. The second part of the study involved a smaller data sub-set gathered from 52 students who volunteered to participate. The smaller data sub-set consisted of scores and times taken for 1 test, answers to the MEQ and self-reported GPA data.

2 REVIEW OF THE LITERATURE

TOD and Aging

A great deal of the literature that exists on TOD is related to aging. These studies compare the effects of TOD on the cognitive abilities of young adults versus older adults (Anderson, et al., 1991; Borella, 2011; Bugg, et al., 2006; Colquhoun, 1971; Folkard, 1982; Folkard & Monk, 1979; Hasher, et al., 2002; Intons-Peterson, et al., 1998; Li, et al., 1998; Martin, et al., 2008; May, 1999; May, et al., 1993; May & Hasher, 1998; Yoon, et al., 2000). Even though this type of comparison was not the focus of this study, this body of literature is still pertinent for several important reasons. For example, a study led by May (1993) established that young adults typically prefer the afternoon and evening hours. As part of a larger study, this team conducted a normative study to determine the sleep-wake patterns for 210 younger adults (aged 18-22) and 91 older adults (aged 66-78). They used the Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976) to determine circadian arousal types for these two groups. The results indicated clear differences between the two groups with the younger adults showing "strong eveningness tendencies" (May, et al., 1993, p. 327). These results have been replicated and cited throughout this body of literature (Allen, et al. 2008; Hasher, et al., 2002; Intons-Peterson, et al., 1998; Li, et al., 1998; May, 1999; May & Hasher, 1998) creating a convincing case that younger adults are typically evening-preferenced.

The studies on TOD effects and aging also show that younger adults process information more quickly in the afternoon and evening hours (May, et al., 1993). This could be due to a phenomenon identified by May and Hasher (1998) as the synchrony effect. This is the idea that cog-

nitive performance is optimal during peak circadian arousal periods (May & Hasher, 1998). Additional studies have intentionally replicated the synchrony effect (May, 1999; Li, et al., 1998). In general, these studies assert that superior cognitive functioning in young and older adults occurs when testing is synchronized with peak circadian arousal periods. Young adults typically experience peak times in the evening, while older adults most commonly experience peak times in the morning.

Some studies found that young adults have an increased sensitivity to distraction and interference in the morning hours which disrupted problem solving performance (May, 1999; Borella, et al., 2011). A study by May (1999) tested the effects of TOD and susceptibility to relevant and irrelevant distractors, taking preferred TOD into account. The study found that younger adults were only significantly affected by irrelevant distractors at off-peak times. May's (1999) study also concluded that relevant distractors (related to the assigned task) could actually benefit subjects who need to perform at off-peak times. These findings suggest that since young adults are typically evening-preferenced that relevant distractions presented to those students during their off-peak TOD could result in a consideration of a "greater breadth of alternatives and hence [lead] to a better solution for tasks requiring creative solutions" (p. 146). These studies blamed the synchrony effect for cognitive discrepancies experienced during off-peak hours (Borella, et.al, 2011; May, 1999).

While the studies on TOD effects and aging do yield information that is relevant to the present study, the tests to determine TOD effects administered within these studies are also important to consider. The earliest of these studies came out in the 1990's and involved assigning non-standardized experimental tasks to each group of participants and recording the data (Intons-Peterson et al., 1998; May, 1999; May & Hasher, 1998). Later studies, such as the one led by

Bennett (2008), used standardized measures of cognitive ability. While standardized tests such as the Wisconsin Card Sorting Task and the Digit Span subset of the WAIS (Bennett, et al., 2008) have been validated to show cognitive function, the abstract nature of these tests make the findings of the studies utilizing them difficult to generalize to the academic environment. This is because the tests involve content that is not relevant to the participants themselves. Further, the study participants may not have put forth the same level of effort for these abstract tasks that a student who is personally invested in their own success would. Finally, the main reason that the results of abstract tests of cognitive ability are not generalizable to an academic setting is that these tests involve the assessment of a specific cognitive ability, whereas academic ability requires an integrated cognitive approach.

While the focus of the present research was not on TOD effects and aging, the findings from TOD and aging research do apply. Even though their focus is on older participants, the use of younger adults as control groups yields valuable insight into TOD effects on that group. Wilson (2004) notes that when searching for research to apply in designing learning environments, one might be hard-pressed to find research that is specific to instructional design. In these cases, we should look to other disciplines, such as educational psychology, and adapt theories to fit our needs.

TOD Effects in Studies Not Related to Aging

There are fewer studies measuring the effects of TOD that are not related to aging. Many of these studies either directly or indirectly confirm the synchrony effect. For example, Callan (1999) tested TOD preference as well as actual TOD effects on algebra test scores for 245 ninth-grade students. This is one of the few studies that tests TOD effects on academic performance.

Callan found that students who preferred the morning scored significantly higher on tests taken in the morning than they did on tests taken in the afternoon. Further, students who preferred the morning scored significantly higher on tests taken in the morning than those students who preferred the afternoon, but took the test in the morning. In a study led by Anderson (1991), "The results suggest that the effect of diurnal variations on memory performance is critically dependent upon whether the subject is a morning or evening type" (p. 241). Both Anderson (1991) and Callan's (1999) findings corroborate the findings of May and Hasher (1998) on the synchrony effect.

In the study led by Allen (2008), researchers attempt to distance their study from the studies on the effects of TOD related to aging by stating that their research is concerned with TOD effects within a specific context (higher education), not age. They do however acknowledge that most college students fall into the young adult category. Without the focus on age, this study is an attempt to replicate earlier studies by Intons-Peterson, et al. (1998), May (1999), May and Hasher (1998) and May et al. (1993), "with an emphasis on assessing multiple cognitive domains longitudinally" (p. 552). The researchers use a series of standardized cognitive tests on 56 college students with mean age of 20.2 years, to test participants on executive control (fluency), processing speed, semantic memory and episodic memory performance at three TOD; 8-10AM, 12-2PM, 6-8PM. TOD preference was determined and tested in this study but failed to show significance. Therefore, these researchers assert that actual TOD is a better indicator of cognitive performance than preferred TOD. They say that TOD preference is related to cognitive performance, but the effects are not the same as actual TOD effects. The results of the Allen et al. (2008) study indicate that working memory performance is affected by TOD effects and that college students generally perform better at tests of fluency and processing speed

in the afternoon and evening hours. Even though Allen et al. (2008) contend that TOD preference was not a factor in these findings, it is important to remember that the literature on TOD effects and aging establish that young adults (the category many college students fall into) are typically evening-preferenced (Hasher, et al., 2002; Intons-Peterson, et al., 1998; Li, et al., 1998; May, et, al., 1993; May, 1999; May & Hasher, 1998). Allen et al. (2008) acknowledges the majority of participants in that study exhibited eveningness tendencies when tested for TOD preference. Since Allen et al. (2008) found that college students performed better at cognitive tasks in the afternoon and evening hours, findings demonstrate the synchrony effect (May, et al., 1993).

There is little literature that tests the effects of TOD on academic performance. Even studies intended to inform policy in K-12 and higher education often involve abstract or standardized tests of cognitive ability, not academic performance (Allen, et al., 2008). For example, in Allen et al. (2008) 56 college students were tested on executive control, processing speed, semantic memory and episodic memory performance using standardized cognitive tests. Another study led by Bennett (2008) tested 77 undergraduate college students on short-term memory, verbal recall, verbal fluency, cognitive flexibility and efficiency using a series of standardized tests. A third study on TOD effects not related to aging that utilizes abstract tests of cognitive ability to determine TOD effects is one led by Manly (2002). This study used a series of clinical tasks to test the effects of TOD on young adults. One study that did use academic performance to measure the effects of TOD was by Callan (1999) which tests the actual TOD effects on algebra test scores for 245 ninth grade students. Again, the use of standardized or clinical tests to determine TOD effects calls the external validity of the study into question, therefore research that utilizes these instruments to test subjects must be consumed with caution.

Some of the research on TOD effects not related to aging is meant to influence school start times for high school students (Callan, 1999; Kirby, Maggi & D'Angiulli 2011; Kowalski & Allen, 1995; Link & Ancoli-Israel, 1995. Carrell, et al. (2011) make the case that the research on high school start time can be generalized to college-aged students. Even though Carrell, et al. (2011) make assertions about high school start times, the actual participants in that study were university level students. They defend their results as generalizable to the population of college students by stating that "like high school seniors, first semester college freshman are still adolescents and have the same biological sleep patterns and preferences as those in their earlier teens" (p. 63).

Kirby, Maggi and D'Angiulli (2011) wrote a review of K-12 school start time literature which cites research indicating that as adolescents become older, they tend to show a natural preference to go to bed later and wake up later. They also cite research indicating that cognitive performance for adolescents fluctuates according to the time of day. In addition, they show research supporting that adolescents experience optimal performance on cognitive tasks measuring executive function when administered late in the day (May, 1999). Kirby, Maggi and D'Angiulli (2011) assert that "this evening preference chronotype is not congruent with early school start times" (p. 60). Callan (1999) also posits that afternoon-preferenced students are at a disadvantage in traditional classrooms.

A study led by Curcio (2006) also found that sleep loss was associated with poor academic performance for adolescents. Kirby, Maggi and D'Angiulli (2011) discuss research supporting that sleep debt contributes to inability to concentrate, memory lapses and decrease in creative thought. Kowalski and Allen (1995) found that students reporting less sleep and going to bed later with irregular wake schedules are more likely to describe themselves as struggling or

failing in school. Link and Ancoli-Israel (1995) found that students who reported higher GPA's also reported less variation in wake times between the weekdays and weekends.

There is also research intended to inform the start time of college classes (Allen, et al.; Trockel, et al., 2000; Carrell, et al., 2011). Allen et al. (2008) suggests that American society, especially with regard to higher education, should re-evaluate the emphasis on morning performance in light of research findings on TOD. Findings indicated that working memory performance in college-aged students is affected by TOD effects, and that college students perform better on tests of fluency and processing speed in the afternoon and evening hours (Allen, et al. 2008). Carrell's (2011) study found a positive causal relationship between the later start time for college classes and academic performance. Not only did subjects experience decreased academic achievement in morning hours when they were required to attend early classes but the earlier wake time negatively affected achievement in courses taken throughout the day. In a study led by Trockel (2000), the effects of several health related variables were analyzed with the GPA of 200 first-year college students. These variables included exercise, eating, sleep, mood, perceived stress, time management, social support, religious habits, number of hours worked, gender and age. "Of all the variables considered, sleep habits, particularly wake-up times accounted for the largest amount in variance in grade point averages (p. 125)." Specifically, the largest negative correlation in the Trockel, et al. (2000) study was between weekday wake-up time and GPA. This implies that the earlier students wake up on weekday mornings, the lower their GPA. There were also significant negative correlations between weekday bedtime, weekend bedtime, weekend wake-up time, and hours of sleep on weekdays and weekends. The intent of the study

led by Trockel (2000) is to advise college students on health-related variables that may affect academic performance. While correlation certainly does not equal causation, findings from this study indicate areas to target for further research.

The studies measuring TOD effects that are not related to aging tell us that the findings on synchrony by May and Hasher (1998) as well as the findings that younger adults tend to be evening types (May, et al., 1993) are generalizable. The gaps in the research with regard to TOD effects on academic achievement, specifically within students' natural learning environments for asynchronous online courses justify, the need for further research. In addition, the findings by Trockel, et al. (2000) on the correlation between sleep habits, wake up times and academic achievement among college students further justifies more research.

Learner Control

Another area of literature that is related to TOD and academic achievement in asynchronous learning environments is learner control. Giving students the option to choose the TOD they take tests in an asynchronous learning environment is allowing them a level of learner control. Johnson and Johnson (2008) define learner control as "delegating instructional decisions to learners so they can determine what help they need, what difficulty level or content density of material they wish to study, in what sequence they wish to learn material, and how much they want to learn" (p. 410). Hooper (1992) notes three forms of instructional control; learner control, program control and adaptive control. Under learner control, students are given some degree of control with regard to pace, content, etc. Under program control the instructional program controls the content, pace, and other aspects of instruction. Adaptive control adapts the lesson ac-

cording to student aptitude, performance or needs. Lowyck (2014) discusses another classification of learner control that is present in the literature; shared control. Shared control involves explicit learner support that allows some learner control but continues to maintain some program control.

The research on learner control is full of discrepancies. On the one hand, research suggests that learner control makes students feel more competent and more intrinsically interested in content (deCharms, 1968; Lepper, 1985) and that when given a choice, learners choose to have instructional control (Kenzie, et al., 1988; Schnackenberg & Sullivan, 2000). Schnackenberg and Sullivan (2000) found learner control achieves the same level of student achievement at a greater rate of favorability. Some research finds that students experience greater achievement when given control over aspects of instruction (Gray, 1987; Kenzie, et al., 1988). Further, research indicates that students do not have to have complete control in order for the positive effects of learner control to be realized. Gray (1987) found that merely giving students control over the sequence of instruction positively affected their post-test scores.

On the other hand, research also suggests that program control may lower a student's motivation because it may require learners to go through information that is unnecessary to the learner or at a pace that is too slow/fast for the learner (Hannafin & Rieber, 1989). There is also research suggesting that program controlled instruction does not result in greater student achievement (Hannafin & Sullivan, 1995; Hannafin & Sullivan, 1996). Hannafin (1984) states that one of the criticisms of program control is the "tacit assumption that the designer is the best judge of when, where and how much instruction is needed to learn a given skill" (p. 6). Researchers also criticize program control, specifically computer assisted instruction, as being too behaviorally based, with generic feedback based on possible behaviors (Lowyck, 2014).

There is also a body of literature suggesting that the effectiveness of learner control depends on the learner (Campbell & Chapman, 1967; Hannafin, 1984; Lowcyk, 2014). Student utilization of embedded support depends on many factors including prior knowledge, self-regulating capacity and attitudes toward learning and the learning environment (Lowcyk, 2014). In addition, learner control is differentially effective depending on these same factors. For example, novice learners or low ability learners do not benefit as much from increased learner control because they lack the prior knowledge needed to organize new information, and they may get lost within the environment because the new information is meaningless for them (Hannafin, 1984; Hicken, et al., 1992; Hannafin & Sullivan, 1995; Hannafin & Sullivan, 1996; Lowcyk, 2014). Hannafin (1984) asserts that younger students perform better under program control while older students are best served with guided learner control. Hannafin (1984) also maintains that students who assume personal responsibility for their achievement perform better under learner control. In addition, learners must adopt the supports and recognize their usefulness in order to maximize their positive effect on learning (Lowcyk, 2014). Finally, there is research in the area of learner control that calls for providing guidance to students when they are given learner control. Studies by DiVesta (1975), and Steinberg (1977) indicate students have difficulty and fail to make wise decisions about content and assess their personal needs in ways that benefit their achievement. Ross and Rakow (1981) found that students who were given instructional control but no guidance made poor instructional choices.

The discrepancies within the learner control research are best understood through the limitations of many of these studies. Reeves (1993) states that many "learner control research studies are flawed in terms of sample sizes, treatment duration, content selection, and other theoretical and methodological issues to such an extent that the research has little value" (p. 7). He cites

examples of researchers that are measuring different ways learners are controlling their instruction, yet are asserting that findings are generalizable and ignoring the different treatments administered, thus making scientific consensus impossible. Further, Reeves states that the design of the research studies themselves is problematic due to brief instructional treatments. For example, Reeves cites the Kenzie and Sullivan article (1989) with mean completion times for the experimental and control groups of about 29 minutes. Reeves cautions that "the instructional treatments used in these studies are usually far too brief to provide learners with sufficient experience for learner control variables to be 'actualized'" (p. 6). Next, Reeves criticizes learner control research for administering treatments on instructional topics that fall outside of the curriculum for the students participating in the study. He notes that introducing topics that fall outside of curriculum or interest of study participants is a threat to internal and external validity. Another fault of Learner Control research that Reeves finds is small sample sizes and large attrition rates. Reeves says that the field of instructional design could benefit from some "well-conceived qualitative inquiry" (p. 9). Instead of conducting quantitative studies with flawed research methodology, Reeves believes we should conduct extensive qualitative research with the goal of observing human behavior in our field, then use that research to develop "meaningful theory that may later be susceptible to quantitative inquiry" (p. 9).

Aside from the need for better research controls and the use of qualitative methods to determine actual student experiences with learner control, the implications of the learner control literature is that more research is needed to clear up the discrepancies. Further, as computer mediated instruction shifts to learning environments, there needs to be more research on learner and program control as applied to online, web-based education. Schnackenberg and Sullivan (2000) note that the increasing popularity of internet-based instruction makes further research into

learner control a necessity. This is "because of the very nature of the Internet and the World Wide Web, virtually all instructional sites have some degree of learner control. Therefore literal program control is not truly an option" (p. 34). One thing Lowcyk (2014) notes as missing from learning environments is metacognitive strategies. He states that the lack of metacognitive strategies is likely due to some remnant of intelligent tutoring system-based design which focuses on domain specific knowledge with one correct answer. Lowcyk (2014) notes that learning environments are goal-oriented which makes the learner's self-regulation very important to success. Brand-Gruwel, et al. (2014) say that a flexible learning environment (FLE) is needed in order to build self-directed learning and self-regulated learning in students. However, they warn against providing a FLE without support and guidance. In sum, more research is needed to test learner control as the nature of computer mediated learning evolves.

Even though the learner control research has been criticized as fundamentally flawed (Reeves, 1993), there are still implications to be drawn from the literature. Along with a balance between learner and program control, instruction should be designed such that learners have some control in order to maintain motivation and to develop self-regulatory skills. However, learner control must include guidance on the appropriate level of support students should utilize based on their ability and prior knowledge. In addition, learner control must be limited when circumstances related to the students or content call for more program control. "There is an important and delicate balance between the goals of individual responsibility and instructional efficiency which designers and researchers should continue to explore" (Hicken, et al., 1992, p. 25).

Lowcyk (2014) says that constructivist learning supports the notion of giving students control, but does not advocate giving learners complete control in line with radical constructivism. Instead, he advocates moderate conceptions of shared control with explicit learner support

such as cognitive apprenticeships, anchored instruction and simulation learning environments because they contain support, allow some learner control, but maintain some program control. Lowcyk's stance is mirrored in earlier work by Kirschner, Sweller and Clark (2006), who criticize minimal guidance approaches as ignoring human cognitive architecture. They use basic cognitive psychology and the Atkinson-Shifron memory model (Atkinson & Shifron, 1968) to show why minimal guidance does not work. They say that the very limited capacity of working memory when processing novel information places a burden on novice learners searching for problem-relevant information which is an expected behavior for learners in minimally guided instruction. Further, the interactions between working memory and long-term memory do not occur for novice learners in minimally guided instruction because the new information cannot be connected to prior knowledge. So, this extended search for information with limited working memory does not result in knowledge acquisition for novice learners. Kirschner, Sweller and Clark (2006) also argue that unguided environments place a high level of cognitive load on novice learners because those students lack the proper schemas to incorporate new knowledge. These writers do not recommend program control however; instead, they advocate guided instruction. Another researcher, Hannafin (1984) suggests providing recommendations to the learner, then leaving the choice up to the student. Under this model, the student's motivation would be increased because they are given some level of control while at the same time guidance is provided, and some program control is maintained. The results of Tennyson and Buttrey's (1980) study indicate that students benefit from learner control only when they were informed about their own particular learning progress and advised on appropriate strategies for achieving mastery, "Students would thus have meaningful information on which to make judgments about the amount and sequence of instruction" (p. 175).

The ideas from the research on learner control can be applied to TOD selection in asynchronous online learning. As Schnackenberg and Sullivan (2000) point out, the evolution of instruction delivered online has led to a decline in program control. TOD selection in asynchronous learning environments is a good example of this decline. The nature of asynchronous online learning allows students to choose the TOD to complete assignments and tests with minimal to no guidance. However, as Lowcyk (2014) and Kirschner, Sweller and Clark (2006) indicate, minimal guidance approaches have been proven ineffective especially for novice learners. Naidu (2008) says that technologies that enable time, pace and place independence for learners are attractive because they open new opportunities for learning and teaching. However, she warns that "inefficient use of these technologies will only lead to blaming the technology for ensuing problems" (Naidu, 2008, p. 265). The literature on learner control does indicate that some level of learner control is beneficial, therefore it is important to maintain students' choice for TOD, but educators need to identify any effects TOD might have on students and provide guidance to learners as suggested by Hannafin (1984), Tennyson and Buttrey (1980).

Literature Synthesis

While the focus of the present study was not on TOD effects and aging, nor was it on school start time or program versus learner control, these areas of literature were important for informing this study. The replicated findings that younger adults typically categorize as evening circadian arousal types (May, 1999) are very important to this study because they build the foundation for the assertions that young adults are at a disadvantage when expected to perform cognitive tasks at certain times of day (Allen, et al., 2008; Callan, 1999; Carrell, et al., 2011; Kirby, et al., 2011; Trockel, et al. 2000). Before building on these findings, it was important to determine

if this sample of students exhibited evening tendencies. Therefore, the MEQ was administered, and those results were analyzed to determine the circadian arousal type for participants.

The discovery, and later replication of the synchrony effect (May & Hasher, 1998), is also crucial to this study because if students experience peak cognitive performance during their peak circadian arousal period, and college students (who are typically younger adults) commonly experience peak circadian arousal during the evening hours, this means that students taking tests in asynchronous online courses might be at a disadvantage during hours others than evening hours. However, the assertions of Allen, et al. (2008) that actual TOD is a better indicator of cognitive performance for college students than preferred TOD needed to be addressed before this study could try to build on the synchrony effect findings. Therefore, this study attempted to replicate the synchrony effect before building on those ideas. In addition, while the literature confirming the synchrony effect would help researchers to conclude that college students may perform better on tests during the evening hours, the wide range of hours used for experiments along with the limited spans of hours in which tests were administered, create questions as to which specific hours young adults could typically expect to experience peak cognitive performance. This study used the actual TOD experiences of students, and their academic performance to indicate specific ranges of time in which students were shown to be more successful. This was possible because instead of using specific time periods to gather data, this study included data gathered at all TOD.

The research on learner control provides a good illustration of why abstract tests of cognitive reasoning used in the TOD literature compromise the validity of the research results. Reeves (1993) criticizes the body of learner control literature for using educational content in study tests that was not related to the participants' academic programs or areas of interest.

Reeves says this practice is a threat to both internal and external validity. He asserts that subjects should be "engaged in learning that is personally meaningful and that has real consequences for them" (Reeves, 1993, p. 7). Reeves (1993) calls for qualitative research on learner control in order to gain insight into student experiences. While it is important to study the personal experiences of students with regard to TOD and academic achievement in asynchronous online courses, the quantitative magnitude of any TOD achievement fluctuations must first be established in order to ground any insight into individual reality, which may be achieved through qualitative inquiry, to the objective reality of this phenomenon. The learner control literature also establishes the idea that complete program control is not possible with web-based instruction (Schnackenberg & Sullivan, 2000). While we may be able to limit the times students take tests in asynchronous online courses through deadlines, the very nature of asynchronous online courses allow students some control over the time they take tests. While the literature establishes that allowing students to maintain some level of control (deCharms, 1968; Gray, 1987; Hannafin & Rieber, 1989; Kenzie, et al., 1988; Lepper, 1985) is advantageous, the findings that guidance should be provided along with learner control are important as well (Hannafin, 1984; Tennyson & Buttrey, 1980). This study is not an attempt to provide a basis for imposing program control or limiting the times that students can take tests in asynchronous online learning environments. Instead, the results of this study are intended to provide guidance for students taking classes online, and for instructors and instructional designers who teach those classes.

3 METHODOLOGY

Conceptual Framework

Objectivism supports the idea that an objective reality exists (Schuh & Barab, 2008). Postpositive researchers see research as series of "logically related steps" (Creswell, 2013, p. 24). While they believe in the concept of individual realities, they use multiple levels and various sources of data to seek validity in the objectivist sense. Postpositivism is exemplified in grounded theory research which involves a systematic process of grounding the researcher's theory through multiple sources of data (Creswell, 2013). It combines inductive and deductive reasoning to maintain a balance between creating a narrative description of individual realities and what Strauss and Corbin (1990) term 'good science.' Grounded theory research encourages the connection between the "macro and micro conditions influencing the phenomenon" (Creswell, 2013, p. 87).

I am interested in TOD effects on academic achievement largely as a result of personal experience as an online instructor. Anecdotally, I have noticed that students take tests in the middle of the night. I have also noticed that a good number of students wait until just before the set deadline to take tests. If this deadline is set late in the evening (Ex: 11:59 PM), this means that students are taking the test late in the evening. I have wondered how the student's TOD selection might influence their ability to take the test and how that might affect their achievement. Logically, it might make sense that students who take tests at certain times of day may be impacted by that TOD selection, but without data to substantiate this logical assumption, there is no way to validate it. From an axiological perspective, I recognize that absolute objectivism is not possible. However, rather than risk advancing my logical assumptions as knowledge in the field of instructional technology, I seek to validate those experiences through quantitative data which

is less subject to bias. Since I have found no quantitative research on TOD effects in an asynchronous learning environment, it is necessary to validate my observations before advising students on TOD selection. I do acknowledge my bias which is rooted in the observations made anecdotally through eight years of teaching online. Therefore, this objectivist scientific approach will be important to understanding this phenomenon. Efforts to control for individual differences using GPA scores were taken in order to help ensure objective findings. Individual differences were acknowledged through the administration of the MEQ (Horne & Ostberg, 1976) to determine TOD preferences, and subsequent analysis of individual circadian arousal types to determine whether synchrony (optimal cognitive performance occurring during peak circadian arousal period) existed for each student. There was no attempt to impose specific times within which students took the tests associated with the data gathered for this study. In addition, students were not limited by place of participation. These tests could be taken at any time or place the student chose. This study took place within the students' natural learning environment which necessarily differs from student to student. Any artificial environmental constraints would have compromised the individual experiences that were essential to this research. This research approach was not deterministic in that the results are not meant to present over-arching truths. These results are simply intended to provide a benchmark of common experiences which have been validated quantitatively. The results may be used to advise students on TOD selection when taking tests online. These results would also be beneficial to any researcher seeking an objectivist basis for critical analysis and grounded theory research which could examine human and other issues after grounding them in the objective reality.

Participants

This research was performed on data which came from one section of an asynchronous online course, "Econ 2106: Principles of Microeconomics" (Econ 2106) administered during the fall 2015 semester at a large southeastern U.S. University. This class was delivered through a learning management system called D2L/Brightspace. There were 84 undergraduate students enrolled in this section of the course. A large data set, as well as a smaller data sub-set was used for this study. Data was taken from all students taking Econ 2106 for the large data set. Data for the small data sub-set came from the 52 students taking Econ 2106 who volunteered to participate.

The course was set up to allow students access to all of the content at the beginning of the semester, but with specific weeks designated for each unit of content. A total of ten tests, including a final exam, which was given in two parts, were scheduled weekly throughout the semester and administered through the LMS. Students had the ability to take tests at any time of day providing that they took the test prior to the deadline which was set at 10:00 PM on Friday evenings (Frost, 2015).

Instruments

In addition to data gathered from the LMS itself, one instrument, a survey (see Appendix B) was used to gather data from the small data sub-set. The survey was launched to volunteers directly through the LMS. It consisted of 31 questions; the first nineteen were taken from Horne and Ostberg's Morningness-Eveningness Questionnaire (1976), a validated survey used extensively in the TOD literature to assess circadian arousal type for research participants (Anderson, et al., 1991; Bennett, et al., 2008; Hasher, et al., 2002; Intons-Peterson, et al., 1998; Li, et al.,

1998; May, 1999; May, et al., 1993; May & Hasher, 1998). A fair use analysis was conducted (see Appendix D), and it was determined that factors weigh in favor of fair use for this survey. In addition, students were asked to self-report their current cumulative GPA. Additional questions included in the survey (see Appendix B) were not included in the data for this study.

Procedures

This study analyzed data on assessment scores of undergraduate students taking an asynchronous online course, TOD of test submission, GPA, and circadian arousal type as determined through MEQ scores. In addition, the tests and test items themselves were analyzed to determine the level of complexity being assessed by each test. Since the best match for a previous study on this topic is the study led by Allen (2008) which utilizes ANOVA, the eta squared value was used to estimate the f^2 value for effect size. Since $\eta^2 = .13$ (large) for Allen's study, $f^2 = .35$ (large) was used. An a priori sample size estimate was then determined as at least 36 participants were needed in order to achieve adequate power of .80 with alpha level of .05. Before splits were performed, the large data set and smaller data sub-set fulfill this sample size estimate.

This research was conducted in two parts; the first part utilized the large data set. In both parts of this study TOD is measured in military time which considers a days' length of time as a 24-hour continuum running from 00:00 hours to 23:59 hours. First, TOD and assessment scores from all students taking the online course on all 10 tests given within that course were used to determine if any achievement patterns in the times of day students take tests could be found. The results of the scatterplot and curve mapping were used to split the data into groups based on TOD and achievement pattern. Next, simple regressions were performed on each set of split data to determine the degree of relationship between scores and TOD for each achievement pattern.

The correlations were analyzed for each set of data and compared to determine if a relationship existed between TOD and assessment scores.

In addition, each test that students took for the course was analyzed to determine the level of cognitive skill required by each test item. The vast majority of items were taken from two published test banks; the Test of Understanding of College Economics (TUCE-4) (Walstad & Rebeck, 2008), and the instructor's resource folder for *Principles of Microeconomics* by Mateer and Coppock (2014). The remaining questions were composed by the instructor.

The work of identifying the cognitive complexity of test items had already been accomplished for the questions that were taken from existing sources. The TUCE-4 uses a modified version of Bloom's taxonomy (1956) to categorize questions by cognitive complexity. Bloom's taxonomy divides cognitive abilities into six levels; knowledge, comprehension, application, analysis, synthesis and evaluation. The levels are arranged by increasing complexity. The TUCE-4 condenses this classification into three categories (Walstad & Rebeck, 2008). Recognition and Understanding (RU), encompasses the lowest two levels within Bloom's Taxonomy. Explicit Application (EA) includes the next two levels within Bloom's Taxonomy. Implicit Application (IA) encompasses the highest levels of complexity. All test items for the TUCE-4 were assigned a numeric score based on their classification as RU, EA or IA. Since RU encompasses the lowest level of cognitive complexity, questions that fell into that category received a score of 1. Questions that were categorized as EA were given a score of 2, and questions in the IA category received a score of 3.

The test bank for *Principles of Microeconomics* (Mateer & Coppock, 2014) ranks the cognitive level of test questions based strictly on Bloom's Taxonomy (1956). Questions are categorized as: Remembering, Understanding, Applying, Analyzing, Evaluating and Synthesizing.

To equate these scores with the cognitive complexity scores assigned by the TUCE-4, they were also assigned a numeric score based on the complexity rankings. Those categorized as Remembering and understanding were assigned a 1. Applying and analyzing questions were assigned a 2, and evaluating and synthesizing questions were given a 3.

Complexity for the instructor-created test items were determined using the same modified version of Bloom's taxonomy used for the TUCE-4 (Walstad & Rebeck, 2008). To perform this analysis, Ph.D. students from the Learning Technologies Division within the College of Education and Human Development at a large southeastern U.S. university were recruited to assist. The six students composing this panel of raters were all familiar with Bloom's Taxonomy (1956) and have all taught professionally at some level.

Raters were presented with a diagram of Bloom's Taxonomy and a description of each level of cognitive ability along with sample action verbs for each level. Then, the cognitive complexity procedure for the TUCE-4 was described and graphically presented on the diagram of Bloom's Taxonomy. Next, raters were presented with three questions that were used on assessments within Econ 2106. These three questions served as anchor questions that exemplified each category from the TUCE-4 cognitive categorization. A question categorized as IA that originally came from the TUCE-4 was presented, along with RU and EA questions from *Principles of Microeconomics* (Mateer & Coppock, 2014). The categorization for each of these questions was discussed, and raters were given the opportunity to ask any questions about rating.

Next, raters were calibrated on the TUCE-4 categorizations using Econ 2106 test questions from the TUCE-4 as well as from *Principles of Microeconomics* (Mateer & Coppock, 2014). To set calibration score requirements for raters, I consulted the literature on assessment

rater calibration. While this literature specifically deals with calibrating those who score assessments holistically, the methods contained are applicable to this study because holistic scoring has the same requirements of assessors being able to make reliable scores despite the human potential for committing errors and/or introducing individual bias.

Moon (2002) set the requirement for raters to correctly score calibration sets at 60%, and this study reported a high exact agreement rate among raters. However, Moon's (2002) study involved a large number of rated items (n = 3,660), therefore the error rate could be large and still maintain the alpha level of .05. Ricker-Pedley (2011) conducted a study examining the link between rater calibration performance and scoring accuracy. That study concluded that rater accuracy on calibration should be set slightly higher than desired scoring accuracy. In addition, Ricker-Pedley (2011) found that calibration tests with as few as 10 questions had a "reasonable correlation with operational accuracy" (Ricker-Pedley, 2011, p. i). In the interest of time, the calibration set for this study was limited to 10 questions as justified by Ricker-Pedley's (2011) study. However, since the alpha level of this study is set at .05, Ricker-Pedley's recommendations that calibration accuracy be set slightly higher than desired scoring accuracy was rejected because this would mean that raters would need to achieve a perfect score on the calibration set before they could rate the cognitive complexity of these questions. This requirement is too stringent and does not allow for human error. Further, the operational set for this study includes only 5 questions. Ricker-Pedley's (2011) study concludes that the requirement of perfect calibration scores resulted in poorer accuracy in scoring shorter operational sets.

One compromise between these two approaches was found in a study by Cash, et al. (2012) which set the calibration score threshold at 80% for adjacent agreement. Adjacent agreement refers to ratings that are adjacent to the correct rating. This means that a rater needed to

score 80% of the calibration with adjacent or exact scores in order to pass calibration. The study led by Cash (2012) concluded that calibrating 2000 raters based on these calibration requirements was successful despite the allowance of adjacent scores. Like Moon's (2002) study, Cash's (2012) study involved a large number of rated items, therefore these tests could risk the large error rate. However, the risk is minimized with the 80% requirement in Cash's (2012) study versus the 60% requirement in Moon's (2002) study. Setting the calibration score requirement at 80% makes sense for this study because it falls at the midpoint between 60% suggested by Moon (2002), and the 100% requirement which would result from adhering to Ricker-Pedley's (2011) recommendations. However, this study will stop short of taking all of Cash's (2012) recommendations for calibration thresholds. The study led by Cash involved a 7 point scale; this study involves a 3 point scale. An adjacent score would have more impact on the validity of the rating for this study. Thus, the calibration threshold for this study was set at 80% exact minimum for the rater to move on to operational rating.

Raters were asked to complete one set of 10 calibration questions before proceeding to operational scoring for the 5 instructor-created questions. Any rater who did not achieve 80% on the first calibration set was asked to re-calibrate using another set of 10 questions from Econ 2106. If a rater failed to achieve 80% on the second calibration set, they were excused from rating,

Once the 5 instructor-created questions had been rated as RU, EA or IA by the panel of Ph.D. students, those ratings were converted to numeric scores (RU = 1; EA = 2; IA = 3). Since the scale used for this analysis only involves 3 possible ratings, the most common indicator of internal consistency (Cronbach's alpha coefficient) is insufficient to determine inter rater relia-

bility (Pallant, 2013). Oosterhof, et al. (2008) says that generalizability across raters can be improved by using multiple raters and averaging their scores. Therefore, the numeric scores for each question were analyzed to determine the mean across raters for each question. These mean scores served as the test item complexity scores for these 5 instructor-created questions.

Finally, SPSS was used to perform a hierarchical multiple regression using the large data set (containing test scores and TOD taken for all students taking Econ 2106 on all 10 tests given) and controlling for test complexity using the complexity scores determined for each test. Since it can naturally be assumed that the complexity of any assessment would affect scores, the goal of this statistical test was to determine how much variance could be attributed to TOD effects after controlling for test complexity.

The second part of this study involved data collected from the 52 students who volunteered to participate in this research (the small data sub-set). It includes survey data, TOD for one assessment, scores for that assessment, and GPA. When students agreed to participate in the study, they also agreed to allow their score on Final Exam Part I and the TOD they took that test to be linked to any survey data gathered from them. Final Exam Part I was chosen because it contains a greater number of questions than contained in Exams 1 – 8, and this part of the Final Exam was given within a similar time frame that the survey was delivered. The increased number of test items strengthens the external validity of any statistical tests involving these scores, and requesting access to recent scores was thought to increase the chances of student consent.

First, SPSS was used to perform a hierarchical multiple regression using TOD, assessment scores and GPA. Findings from the first part of this study on achievement patterns with TOD and resulting correlation were used to specify the TOD group used for this statistical test. Self-reported GPA data obtained from the surveys was utilized to determine if TOD could be

used to predict assessment scores when GPA effect was controlled. Next, the partial correlation between TOD and test scores was analyzed to determine the strength of the linear relationship between the two variables after controlling for individual differences using GPA.

Finally, the results of the MEQ (questions 1-19 of the survey) were determined using the scoring guidelines outlined by Horne & Ostberg (1976). The MEQ scores, along with the actual TOD students took Final Exam Part I were used to perform a factorial ANOVA in order to quantitatively determine if mismatching TOD preference with actual TOD affects achievement. In addition, the difference in mean scores between groups taking tests at peak versus off-peak TOD were examined. The results indicate whether synchrony exists within this data sub-set (May & Hasher, 1998).

Table 1
Research Question, Data Source and Test

Research Question	Data Source	Statistical Test
Is there a correlation between TOD and academic achievement on multiple-choice assessments within asynchronous online courses?	Large data set (all) Small data sub set (GPA, test scores, TOD)	
a. What achievement patterns can be found in the TOD students in asynchronous online classes choose to take tests?	Large data set (test scores, TOD)	Scatterplot; curve mapping
b. What is the degree of the relationship between TOD and achievement within those achievement patterns?	Large data set (test scores, TOD)	Simple regressions on split data
c. Are TOD effects different depending on the level of cognitive ability being measured by the assessment?	Large data set (test scores, TOD, tests, test items, complexity)	Hierarchical multiple regression (test complexity, TOD, test scores)
d. After controlling for individual differences in overall academic achievement using GPA, can TOD be used to predict scores on assessments taken in an asynchronous learning environment?	Small data sub set (GPA, test scores, TOD)	Hierarchical multiple regression (GPA, test scores, TOD)
What role do circadian arousal types play in the relationship between TOD and achievement on assessments given in an asynchronous learning environment?	Small data sub set (survey data, MEQ scores, GPA, test scores, TOD)	ANOVA (MEQ X TOD)

4 RESULTS

For the first part of this study, the large data set consisting of scores from 84 Econ 2106 students on all 10 tests with TOD taken was analyzed. The total number of scores was reduced to 686 due to students not taking all of the tests. The syllabus for this course describes an extra credit situation which allows for students to miss one test each (Frost, 2015). In addition, tests were not allowed to be taken late or made up if missed (Frost, 2015), this resulted in some missing scores on tests.

First it was necessary to test the linearity of the relationship between TOD and assessment scores. SPSS was used to perform a linear regression curve estimation using score as the dependent variable and TOD as the independent variable. The resulting scatterplot is shown (see Figure 1). Note that TOD is shown in military time. The linear fit line represents the linear model. The jagged line represents the observed data.

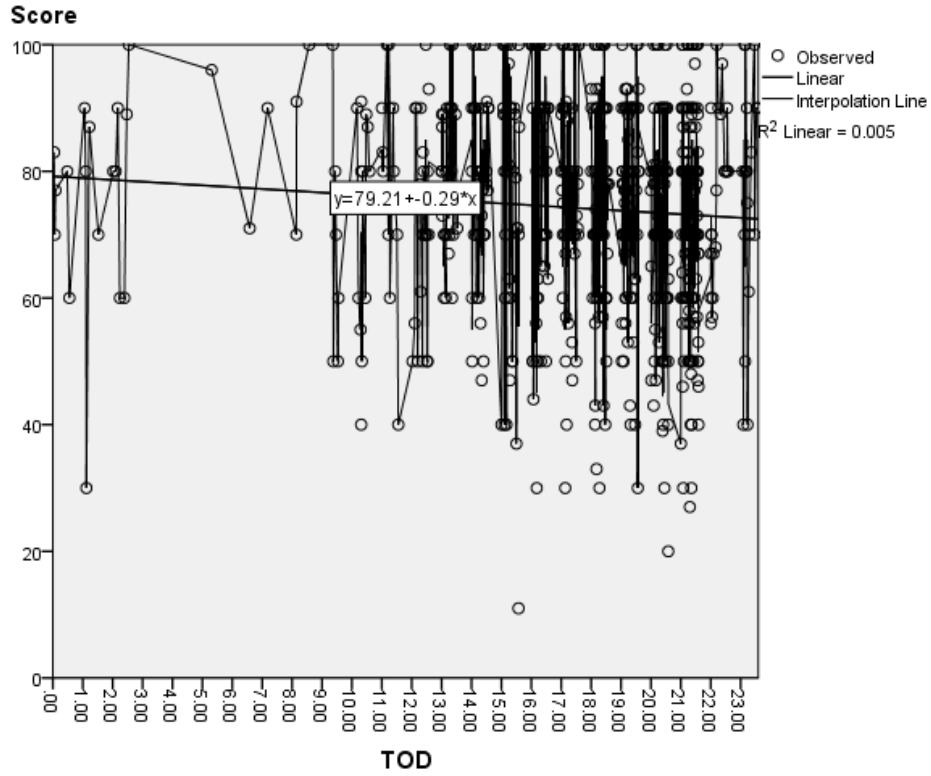

Figure 1. Linear Regression Curve Estimation between Score and TOD

While these lines clearly do not mirror each other, the non-linear relationship is not evident from the scatterplot. However, the *F*-test did not produce a significant result, F (1, 678) = 3.572, p = .059. This means that the linear model is a poor fit for determining the relationship between TOD and assessment scores for this data(see Table 2).

Table 2

Linear Regression Curve Estimation on Large Data Set

Group	F	df1	df2	Sig.
All	3.572	1	678	.059

While only slightly non-linear, the relationship between TOD and assessment scores cannot be determined using correlation. However, splitting the data into groups in which these variables do exhibit a linear relationship would make it possible to determine the degree of correlation. In order to rationalize any split in the data, a locally weighted polynomial regression (LOESS) line was added to a scatterplot of the TOD and assessment score data, and compared with the linear regression line (see Figure 2).

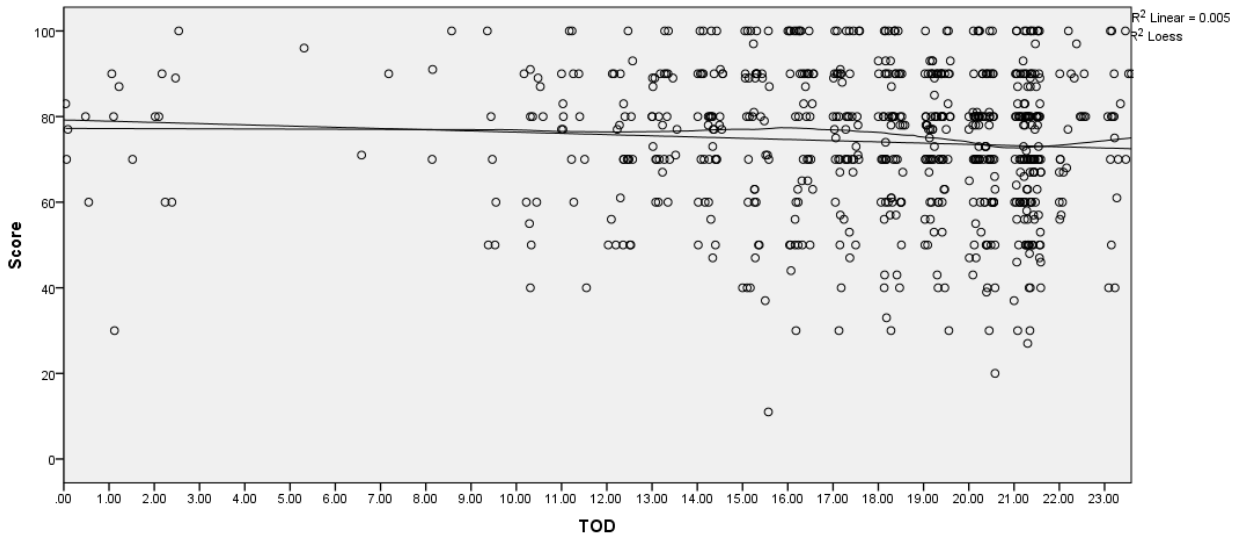

Figure 2. Linear Regression versus LOESS TOD and Assessment Scores

LOESS was originally developed by Cleveland (1979) and Cleveland and Devlin (1988), and can be used when linear regression procedures are inappropriate due to violation of the statistical assumption of linearity (NIST, 4.1.4.4). LOESS was used for this study because of the ability it affords researchers to determine the local variation in the data point by point making it easier to segment that data based on local variation versus the global variation shown in a linear regression model (NIST, 4.1.4.4). As shown in Figure 2, the LOESS line curves to intersect with the linear regression line at 7:00 hours. It then curves again at 11:00 hours, 16:00 hours, and 22:00 hours. These curves in the LOESS line indicate the rise and fall of mean assessment scores across time. Since the goal of introducing the LOESS line was to split the data into groups which could exhibit a linear relationship, thus showing achievement patterns, the curves were used to split the scores based on the TOD tests were taken. Therefore, the large data set was split into 5 groups (see Table 3). Note that time periods are not equal segments because they are based on the differences between the LOESS line and the linear regression line instead of on hourly increments.

Table 3

Large Data Set Split by TOD

Group	TOD
1	0.00 – 7:00 hours
2	7:01 – 11:00 hours
3	11:01 – 16:00 hours
4	16:01 – 22:00 hours
5	22:01 – 23:59 hours

Next, SPSS was used to perform linear regression curve estimations on each set of split data using score as the dependent variable and TOD as the independent variable. This test revealed no significant linear relationship between TOD and assessment scores for groups 1, 2, 3 and 5 with alpha set at .05. It should be noted that non-significant findings for TOD groups 1, 2, 3, and 5 could be attributable to low numbers in those groups (Group 1, $N = 19$; Group 2, $N = 24$, Group 3, $N = 141$; Group 4, $N = 459$; Group 5, $N = 37$). However, a significant linear relationship between TOD and assessment scores was determined for tests in this data set taken between 16:01 and 22:00 hours (see Table 4).

Table 4

Linear Regression Curve Estimations on Split Data

Group	F	df1	df2	Sig.
1	.555	1	17	.466
2	.811	1	22	.378
3	.007	1	139	.932
4	6.443	1	457	.011*
5	.227	1	35	.637

*Significant at $\alpha = .05$

Since TOD and assessment scores only had a significant linear relationship between 16:01 and 22:00 hours, that is the only TOD that could be investigated using the Pearson *r* correlation coefficient. This test revealed a slight negative correlation between the two variables with lower scores associated with later TOD (r = -.118, n = 459, p = .011). Mean scores for tests taken later in this time period were significantly lower than mean scores for tests taken earlier in the time period.

In order to mitigate any extraneous factors related to the tests themselves, we wanted to see if the complexity of tests played a role in any TOD effects that were significant. Table 5 shows the cognitive complexity scores on a scale of 1-3 for each test given in Econ 2106.

Table 5

Test Complexity Econ 2106

Test	Complexity
Exam 1	1.46
Exam 2	1.44
Exam 3	1.44
Exam 4	1.80
Exam 5	1.20
Exam 6	1.40
Exam 7	1.60
Exam 8	1.33
Final Exam 1	1.48
Final Exam 2	1.53

Since TOD effects were only significant during the TOD between 16:01 and 22:00 hours, scores, TOD and test complexity from that TOD only were used to perform a hierarchical multiple regression in order to assess the TOD effects on assessment scores, after controlling for the influ-

ence of test complexity. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Test complexity was entered first, explaining 1.2% of the variance in assessment score, F (1, 457) = 5.35, p = .021. Next, both TOD and test complexity were entered into the statistical model, and were found to explain 2.5% of the variance in assessment score, F (2, 456) = 5.84, p = .003. TOD was found to account for 1.3% of the total variance in score after controlling for test complexity, *R* squared change = .013, F change (1, 456) = 6.28, p = .013. In the final model between the hours of 16:01 and 22:00, both TOD and test complexity were found to have a statistically significant effect on assessment scores, with test complexity only recording a slightly higher beta value (*beta* = -.105, p = .023) than TOD (*beta* = -.116, p = .013). Tables 6 and 7 show the results and effect size for this hierarchical multiple regression.

Table 6

Hierarchical Multiple Regression Scores, TOD Controlling for Test Complexity

Model	R Square	F	R Square Change	df1	df2	Sig. F Change
1	.012	5.350	.012	1	457	.021
2	.025	5.844	.013	1	456	.013

Table 7

Effect Size Hierarchical Multiple Regression Scores, TOD Controlling for Test Complexity

	Beta	Sig.
Test Complexity	-.105	.023
TOD	-.116	.013

The second part of this study consisted of analyzing a small data sub-set based on the findings from the analysis of the larger data set. This smaller sub-set includes test scores for one test (Final Exam Part I) as well as MEQ scores and self-reported GPA data. To begin, assessment scores, TOD taken and GPA were used to run a heirarchical multiple regression in order to assess the TOD effects on assessment scores after controlling for individual differences in overall academic achievement using GPA. Three students who consented to participate in the second part of this study chose not to disclose their GPA, therefore this analysis excluded those cases. In addition, since the analysis performed in the first part of this study revealed that TOD effects were only significant between the hours of 16:01 and 22:00, only the test scores and GPA data from that specific TOD were used for this analysis. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. GPA was entered into the model first, explaining 3.1% of the variance in assessment score $F(1, 32) = 1.02$, $p = .32$. Next, both TOD and GPA were entered into the statistical model, and were found to explain 11.8% of the variance in assessment score, $F(1,31) = 2.08$, $p = .14$. TOD was found to account for 8.7% of the total variance in assessment score after controlling for GPA, *R* squared change = .087, *F* change (1,31) = 3.07, $p = .09$. In the final model, neither TOD (*beta* = -.296, $p = .09$) nor GPA (*beta* = .166, $p = .33$) were found to have a statistically significant effect on assessment scores. Therefore TOD cannot be used to predict scores on assessments for this set of data. Tables 8 and 9 show the results and effect size for this hierarchical multiple regression.

Table 8

Hierarchical Multiple Regression Small Data Sub-set Scores, TOD, Controlling for GPA

Model	R Square	F	R Square Change	df1	df2	Sig. F Change
1	.031	1.016	.031	1	32	.321
2	.118	2.076	.087	1	31	.090

Table 9

Effect Size Hierarchical Multiple Regression Small Data Sub-set Scores, TOD, Controlling for GPA

	Beta	Sig.
GPA	.166	.332
TOD	-.296	.090

Finally, the synchrony effect was tested on the small data sub-set by performing a 3 X 2 ANOVA on MEQ categories (morning, evening, neutral) and TOD (AM or PM). First, the cases in the small data sub-set were divided into groups based on the TOD they took the test (Group 1 = AM; Group 2 = PM). Next numeric MEQ scores were converted to categories based on the recommendations made by Horne and Ostberg (1976). They recommended five categories; definitely morning (70-86), moderately morning (59-69), neither type (42-58), moderately evening (31-41), and definitely evening type (16-30). Of the 54 volunteers who participated in the survey containing the MEQ, 52 completed the MEQ. In an attempt to ensure adequate membership in each group for MEQ, Horne and Ostberg's five categories were condensed to 3; Group 1 = morning (59-86), Group 2 = neither type (42-58), and Group 3 = evening (16-41). The precedent for condensing Horne and Osberg's MEQ categories has been made in the literature on TOD effects (Anderson, et al., 1991; Bennett, et al., 2008; Hasher, et al., 2002). The interaction effect between TOD and MEQ was not statistically significant, F (1, 47) = .18, p

= .67. Further, there was no statistically significant main effect for TOD (F (1, 47) = .49, p = .49) or MEQ (F (2, 47) = 1.35, p = .27).

Table 10

Factorial ANOVA Small Data Sub-set TOD, MEQ

Source	df	F	Sig.
TOD	1	.486	.489
MEQ	2	1.350	.269
TOD * MEQ	1	.184	.670

However, there was an anecdotal difference noted between the mean scores for those who identified as neither type versus those identifying as evening types on the MEQ. Students who identified as evening types and took the test during the PM hours had a mean score of 75.63 (*SD* = 10.15) and those who identified as neither type, but took the test during the PM hours had a mean score of 65.75 (*SD* = 11.84). Table 11 shows the descriptive statistics for these MEQ types.

Table 11

Descriptive Statistics Small Data Sub-set, Neither Types and Evening Types

Group	N	M	SD
Neither	24	65.75	11.844
Evening	19	75.63	10.145
Total	43	70.12	12.066

To explore this mean difference, an additional one way ANOVA was performed to determine if there was a significant difference in assessment scores between evening types who

took the test during the PM hours, and those who categorized as neither type and took the test in the PM hours. For this test, only test scores from the PM TOD were used. Once all of the scores from the AM hours and all of those from students who identified as morning types had been removed, the small data sub-set contained 43 scores and MEQ types. For those who took the test during the PM hours, there was a statistically significant difference in mean scores for Final Exam Part I between students who identified as neither type on the MEQ versus those who identified as evening types, F (1,41) = 8.36, p = .006. See Table 12.

Table 12

ANOVA Small Data Sub-set TOD, MEQ

	df	F	Sig.
Between Groups	1	8.359	.006
Within Groups	41		
Total	42		

5 DISCUSSION

Overview

This quantitative study set out to answer two over-arching research questions. First, what is the relationship between TOD and academic achievement on multiple-choice assessments within an asynchronous online course? Second, what role does circadian arousal type play in the relationship between TOD and achievement on assessments in an asynchronous learning environment? To answer these questions, test scores and TOD for 84 students taking 10 tests as part of an undergraduate economics course that was delivered asynchronously online are analyzed. To help eliminate extraneous factors related to the tests themselves, the role of test complexity in determining assessment scores is analyzed and compared with TOD effect. For the second part of this study, 54 volunteers completed a survey and responses were linked to their scores on one test and the time that test was taken. This smaller data sub-set was examined to determine how TOD affected scores when GPA was controlled and the role circadian arousal type played in TOD effects.

Research Question #1

This study investigated the relationship between TOD and academic achievement on multiple choice assessments given within an asynchronous online course. A curvilinear relationship was predicted, so it was first necessary to rule out a linear relationship. This was accomplished with the linear regression curve estimation between TOD and assessment scores. The findings show that when test scores from this data set were examined over a 24-hour time period a linear relationship did not exist between these two variables. The LOESS line confirmed the curvilinear relationship, and allowed for TOD to be segmented using the differences in the linear

regression and LOESS lines on the data scatterplot. This established the achievement patterns in the times students in this asynchronous class chose to take tests. However, only one of these achievement patterns was found to be significant for this asynchronous online class. Through analyzing the five segments of time, a significant linear relationship between TOD and assessment scores was found between 16:01 and 22:00 hours, F (1, 457) = 6.44, p = .011. The results of this study show that during the remaining time periods (0:00 to 7:00, 7:01 to 11:00, 11:01 to 16:00, and 22:01 to 23:49) achievement on tests for this course had little to no relationship with the time the test was taken.

The significant achievement pattern found between 16:01 and 22:00 hours was then analyzed to determine the degree of relationship between TOD and assessment scores for this asynchronous course. Although correlation does not equal causation, a slight negative correlation (r = -.118, n = 459, p = .011) between TOD and assessment scores between 16:01 and 22:00 hours would indicate that the later students took tests during this time period, the lower their scores on tests for this course were. Although significant, the effect size for this sample was small.

Since the only significant TOD effect could be found between 16:01 and 22:00 hours, I wanted to determine the magnitude of the TOD effect when extraneous factors related to the tests themselves were controlled. Test complexity based on a modified version of Bloom's Taxonomy (1956) was calculated for each test given in Econ 2106 over the course of this semester. These complexity scores were analyzed along with assessment scores and TOD between 16:01 and 22:00 hours. As expected, test complexity was found to have a statistically significant effect on assessment scores accounting for 1.2% of the variance, F (1, 457) = 5.35, p = .021. It is interesting to note is that once test complexity for this TOD group was statistically controlled, TOD still accounted for 1.3% of the total variance in score between 16:01 and 22:00 hours, F change

(1, 456) = 6.28, p = .013. Thus, there was a significant TOD effect for students taking tests between 16:01 and 22:00 hours within this asynchronous online learning environment (*beta* = -.116, p = .013). In addition, the effect size for test complexity was comparable to that of TOD. Since the standard deviation for the mean (M = 73.26) of all tests taken between 16:01 and 22:00 hours was 16.90, when analyzed with the effect size, TOD was found to affect test scores by as much as -1.96 points. Test complexity was found to affect test scores by as much as -1.77 points (*beta* = -.105, p = .023). This means that there is not only a TOD effect found for students taking this asynchronous course during this time period, but that TOD effect is comparable to any effect that test complexity would have on assessment scores.

Next, the findings from the first part of this study were used to analyze the smaller data sub-set as further analysis of the relationship between TOD and assessment scores for this asynchronous course. Since the only significant TOD effect for students taking Econ 2106 was found was between 16:01 and 22:00 hours, this TOD was used to determine if TOD could be used to predict scores on assessments taken in asynchronous learning environments after controlling for individual academic achievement using GPA data. Since the smaller data set only included assessment scores from one test, it was no longer necessary to control for test complexity. Of the students that volunteered to participate in the second part of this research study, 34 disclosed their GPA through the survey and took Final Exam Part I between 16:01 and 22:00 hours. The mean score on this exam among study volunteers was 68 (SD = 12.15), and the test complexity for this exam was 1.48 out of 3.0. The mean complexity score for the 10 assessments given in Econ 2106 was 1.46/3.0 (SD = .16). Final Exam Part I was only slightly more complex than the mean complexity for tests given in the course, yet the mean score among these students was below the 74.18 mean score (SD = 16.83) for all tests taken at all times of day. It is interesting to

note that Final Exam Part I was a cumulative test, so lower mean scores could be attributable to the greater amount of content being tested with that assessment. However, some of the questions that were contained in Final Exam Part I had appeared on earlier tests throughout the semester, giving students a slight advantage. The hierarchical multiple regression used to control for GPA effects on scores for Final Exam Part I revealed that together GPA and TOD explained 11.8% of the variance in assessment score for this small data sub-set, with 8.7% of that variance attributed to TOD compared to the 3.1% that could be attributed to GPA, *R* squared change = .087, *F* change (1,31) = 3.07, *p* = .09. The implication is that individual academic achievement as factored using GPA, contributed less to a student's achievement on Final Exam Part I than TOD did. However, confounding variables negate the argument that TOD has a greater effect on assessment scores than individual academic achievement. In addition, despite these findings, neither TOD (*beta* = -.296, *p* = .09) nor GPA (*beta* = .166, *p* = .33) were found to have a statistically significant effect on assessment scores.

In sum, this study did find a relationship between TOD and assessment scores on multiple choice assessments given in an asynchronous online learning environment, but only between the hours of 16:01 and 22:00. When analyzed using the large data set, TOD was found to contribute significantly to the variance in test scores when text complexity was statistically controlled. While TOD's contribution to variance in assessment scores was only statistically significant when analyzed with the large data set, this fact could be due to the larger number of scores taken between 16:01 and 22:00 hours that were used for the first part of this study (*N* = 459) than for the second part of this study (*N* = 34). As Minium, et al. (1999) point out, "As sample size increases, so does the accuracy of the sample statistic as an estimate of the population parameter" (Minium, et. al, 1999, p. 192).

Research Question #2

This study investigated whether circadian arousal types play a role in the relationship between TOD and achievement on assessments given in an asynchronous learning environment. Basically, this study set out to replicate the synchrony effect documented by May & Hasher (1998). At first glance the results of the 3X2 ANOVA show that the synchrony effect was not replicated in this study. However, closer examination of the data reveals that only 4 students in the small data sub-set were categorized as morning types. Further, only 5 students took the test during the AM hours. These sample sizes are insufficient to draw conclusions for the interaction of TOD and MEQ for morning types.

These low numbers are not surprising. In a study led by May (1993), it was established that young adults typically prefer the afternoon and evening hours. Insufficient sample sizes for groups of young adults who categorize as morning types and older adults who categorize as evening types is seen throughout the literature on synchrony. In fact, May and Hasher (1998) had this issue within the study establishing the synchrony effect. When screening candidates for participation in that study, only 5% of young adults categorized as morning types, and only 2% of older adults categorized as evening types (May & Hasher, 1998). With 1,927 participants screened for that study, these low percentages reflect the magnitude of the difficulty in obtaining an adequate sample size to test young adult morning types and older adult evening types during off-peak times. Instead, May and Hasher (1998) used only young adults who categorized as evening types and only older adults who categorized as morning types. In other words they only used younger and older adults with typical MEQ types (May, et al., 1993). May and Hasher (1998) then used repeated measures testing procedures to test younger and older adult groups

during the morning hours and evening hours to compare the results. That study was conducted in a laboratory setting as a controlled experiment. By contrast, this research was aimed at studying TOD effects in students' natural learning environments for asynchronous online learning. No attempt to control the times within which students could take tests was taken. Since the tests were course-related, and that course only allowed one attempt at assessments (Frost, 2015), repeated measures testing was not possible. Therefore, the ability to detect the synchrony effect was much more limited for this research. Considering the diminished ability to detect synchrony meant that we had to look beyond the 3 X 2 ANOVA results in order to determine if synchrony was at play with this sample.

The descriptive statistics revealed that the majority of the 52 students who volunteered for the second part of this study took Final Exam Part I in the PM hours (N = 47). The difference in mean score between those who were categorized as neither type (M = 66.19 , SD = 11.48, p = .008) and those who were categorized as evening types (M = 75.82 , SD = 9.72, p = .008) reveals that students who took tests in the evening hours AND categorized as evening types performed better on tests. This makes sense considering that according to the research on the synchrony effect, evening types can expect peak performance in the evening, while neither types can expect to experience peak performance in the early afternoon and then again in the evening (May & Hasher, 1998). However, the circadian peaks expected for neither types are not as great as those experienced by the evening types, and the troughs between circadian arousal peaks are much lower for neither types (Horne and Ostberg, 1976). In general, those who categorize as niether types can expect to experience more sustained periods of peak circadian arousal, but their peaks are lower in amplitude than either morning or evening MEQ types (Horne & Ostberg, 1976).

Therefore, the mean score differences between those who categorized as evening types taking tests during evening times and those who categorized as neither MEQ type taking tests during the evening times confirm presence of the synchrony effect among evening circadian arousal types taking tests in the evening within Econ 2106. The small data sub-set only involved scores and TOD taken for one test. Perhaps if multiple tests were included for these students, there would be more variation in the TOD students took tests. Since synchrony was partially confirmed this sample suggests that if more tests were included with a larger sample of asynchronous online students, synchrony could be shown. However, further research needs to be conducted in order to confirm this. While evidence of synchrony is more limited in this study than the synchrony results seen in previous studies, findings may be more generalizable to best practices in online education because this research was conducted under terms and in environments experienced in asynchronous learning.

Conclusions

This investigation resulted in some meaningful conclusions about TOD effects on asynchronous online assessment scores. First, a TOD effect was found to be significant for students in this asynchronous course taking tests between the hours of 16:01 and 22:00. Econ 2106 students taking tests online during these hours could expect as much as 1.4% (R^2 = .014) negative effect on their grade the later they took the test during this time period. Test complexity played a significant role in determining assessment scores in this asynchronous learning environment, but the role of TOD within this sample was comparable to that of test complexity. When analyzed using the smaller data sub-set neither GPA nor TOD could be used to predict student scores on asynchronous tests. Finally, the full model of the synchrony effect could not be confirmed for

students taking Econ 2106, but evidence that synchrony exists for some students in this study was found.

Implications

When placed into the larger context of asynchronous online learning and student achievement, these findings have the following implications for those teaching online courses, as well as those taking online courses:

1. Students, instructors and instructional designers should consider TOD as a factor affecting achievement in asynchronous learning environments.
2. Synchrony could contribute to student success in asynchronous online courses.
3. While young adults may perform better on asynchronous assessments when taken during evening hours, this positive TOD effect may eventually decline the later students choose to take tests.
4. We can naturally assume that the cognitive complexity of an assessment will affect achievement, however we cannot ignore that TOD could play a comparable role when tests are taken in an asynchronous learning environment.
5. Variance attributable to TOD effect on asynchronous test scores could be converted to score impact. The practical importance of score difference could influence students to adjust the times they take asynchronous online tests.

Next, I will discuss how each of these implications affects online student success. I will also compare these implications with existing literature. Finally, I will show how each implication contributes to knowledge in the field.

Implication #1

Students, instructors and instructional designers should consider TOD as a factor affecting achievement in asynchronous learning environments. TOD was found to be a significant factor affecting achievement between 16:01 and 22:00 hours for students taking tests in this asynchronous online course. The implication of this finding is magnified because of the 680 total assessment scores from 84 students used for the large data set, 459 of those scores were achieved between 16:01 and 22:00 hours. Since no effort was taken to control students' natural learning environments for this study, students chose the TOD they took tests. Whether out of necessity or preference, students in this asynchronous online course chose to take tests between 16:01 and 22:00 hours at a greater rate than in the other times of day. Over half of the tests (68%) from all students taking this asynchronous online course were taken between 16:01 and 22:00 hours. If this test-taking pattern is indicative of patterns in other asynchronous courses, it is important to consider the role TOD may play in achievement during this time period. It is also important to make students aware that TOD effects may impact their achievement in asynchronous courses.

While I am not advocating for program control over the TOD students take tests in asynchronous learning environments, allowing students to choose the TOD they take tests without direction is equal to allowing learner control without guidance. I agree with Hannafin (1984), who suggests providing recommendations to the learner, then leaving choices up to the student. Under this model, students would be given the freedom to choose their testing times, but provided with guidance on optimal testing times based on age and MEQ. Therefore, it would follow that the student's motivation would be increased because they are given some level of control, while at the same time, guidance would be provided with the choice to heed that guidance left to the

student. The results of Tennyson and Buttrey's (1980) study indicate that students benefitted from learner control only when they were informed about their own particular learning progress and advised on appropriate strategies for achieving mastery, "Students would thus have meaningful information on which to make judgments about the amount and sequence of instruction (p. 175).

Within computer-enhanced learning environments, educators make recommendations and provide tools for the learner to adapt instruction to fit their individual needs. If research indicates that the selection of certain times of day could impact student performance on assessments, and students taking asynchronous courses are choosing to take tests during those times, educators should not expect students to discover whether TOD impacts their achievement through a minimally guided approach. At the same time, educators should not intervene and set program control over the time students take tests. After all, one draw to online learning is open accessibility. Students need to retain the ability to learn, complete assignments and take tests where and when it is convenient for them. To place limits on the accessibility of online education would serve to limit the opportunity that online education brings to those who rely on that convenience. Instead, educators need to make students aware that TOD could play a role in their achievement and let them decide for themselves if they want to adapt the time they take tests. Lowcyk (2014) notes that metacognitive strategies are noticeably missing from learning environments, and since learning environments are goal-oriented, the learner's self-regulation and metacognition are very important to success. Providing the research findings on TOD effects would allow students to reflect on their own learning and cognitive ability, and help to foster an awareness of any limitations that TOD may place on their individual ability to achieve success when learning online. That way learners can work to adapt their behavior and strategies to fit their own learning needs.

The implication that TOD should be considered as a factor affecting student achievement in asynchronous online courses is meaningful because it represents something new in the research. One gap noted in the research on TOD and academic achievement is that few studies research TOD effects within students' natural learning environments. Further, I did not find any research on TOD effects within asynchronous online learning environments. The finding that TOD effects were statistically significant in this asynchronous online learning environment between the hours of 16:01 to 22:00, establishes a new area of research on TOD and best practices in online education. In addition, the number of scores analyzed for the non-significant time segments were all lower (0:00 to 7:00, $N = 19$; 7:01 to 11:00, $N = 24$; 11:01 to 16:00, $N = 141$; 22:01 to 23:49, $N = 37$) than the number of scores on tests taken between 16:01 and 22:00 hours that were analyzed. Perhaps a relationship between TOD and assessment achievement in asynchronous courses could be found with larger numbers analyzed for each TOD. Now that it is established that TOD should be considered as a factor affecting student achievement in asynchronous online courses, further research is needed.

Implication #2

Synchrony could contribute to student success in asynchronous online courses. The synchrony effect is the idea that a person's peak cognitive performance occurs during their peak circadian arousal period (May & Hasher, 1998). While this study did not show that synchrony existed among all students taking this asynchronous online course, there is evidence that synchrony was at play for some students. The statistically significant higher mean score among students who identified as evening types taking tests in the evening versus mean scores for those who identified as neither type and took the test in the evening shows that synchrony existed for the

evening type students allowing them to achieve greater success than the neither types when taking Final Exam Part I. The implication is that students taking asynchronous online courses should be made aware of their peak circadian arousal type, and then provided with advice on optimal testing times in order to better ensure success when taking tests online.

In this study, the fully crossed design of MEQ type X TOD was impossible due to the low number of students who categorized as morning types ($N = 4$). The low number of morning types corresponds to the age group of these students. May, et al. (1993) established the idea that young adults typically categorize as evening types, while older adults overwhelmingly categorize as morning types. The data for this study was taken from a group of undergraduate students at an institution where the average age of undergraduate students is 24 (Georgia State University Office of Institutional Effectiveness, 2013-2014). Since it would be fair to assume that most of the students taking Econ 2106 fall into the category of young adults, the low number of morning MEQ types is not surprising.

Since May and Hasher (1998) first reported on the synchrony effect, it has been replicated in a number of studies on TOD (Anderson, et al., 1991; Callan, 1999; Li, et al., 1998; May, 1999). For example, Callan (1999) concluded that students who took tests during their peak circadian arousal time as determined by the MEQ, scored higher on algebra tests than those taking tests during off-peak circadian arousal periods. Callan's study is pertinent to this study because its results were replicated; evening types in this study scored higher on tests taken in the evening than neither types taking tests during that same period of time (16:01 to 22:00 hours). In addition, Callan's study is one of the few studies that produced findings on academic achievement versus achievement on abstract tests of cognitive ability given in a clinical setting. Like this study, Callan's study gathered data from students in their natural learning environment. This

study differs from Callan's in that this study researched academic performance in an asynchronous online learning environment versus a traditional classroom setting.

The implication that synchrony could contribute to student success in online courses is important because it represents something new in the evolution of literature on TOD effects. Earlier studies tested the synchrony effect by assessing students on abstract cognitive reasoning exams in clinical settings (Anderson, et al., 1991; Li, et al., 1998; May, 1999), then Callan (1999) tested the synchrony effect in a traditional classroom setting using academic measures of achievement. This study tested the synchrony effect using academic measures of achievement within students' natural learning environment for asynchronous online learning. One implication that Callan (1999) notes for his study is "Where given a choice of time of test taking, students should be advised to take their tests at their preferred time of day" (Callan, 1999, p. 299). In asynchronous online courses, students are given unlimited choice for time of testing as long as they meet deadlines. This study's findings on the synchrony effect builds on the implication from Callan's (1991) study. Students should be advised on identifying their peak circadian arousal period, and advised to take tests during that time.

Implication #3

While young adults may perform better on asynchronous assessments when taken during evening hours, this positive TOD effect may eventually decline the later students choose to take tests. The slight negative correlation (r = -.118, n = 459, p = .011) found within this data set between TOD and assessment scores for tests taken between 16:01 and 22:00 hours would indicate that the later students took tests during this time period, the lower their scores were. This means that advising evening type students to take tests in the evening may not be effective unless we

specify what we mean by 'evening.' Upon examining the difference between the linear regression and the LOESS lines for the large data set in this study (see Figure 2), we see that achievement peaks at about 16:01 hours, then steadily declines until 22:00 hours. Since this is the only TOD where statistical significance was found, we can only objectively discuss this time period. Therefore, advising students who categorize as evening types to take tests earlier in the evening as opposed to later in the evening would have the best probability of ensuring success among these MEQ types.

I was unable to find any TOD research that tested students on a 24-hour scale. The studies in the body of literature on TOD test students at specific times. Typically morning times of testing were between 8 AM and 10 AM (8:00 to 10:00 hours), afternoon testing was between 12:00 PM and 5:00 PM (12:00 to 17:00 hours), and evening testing times ranged from 5:00 PM to 8:00 PM (17:00 to 20:00 hours) (Allen, et al., and 2008; Anderson, et al., 1991; Bennett, et al., 2008; Borella, 2011; Callan, 1999; May, et al., 1993; May, 1999). For example, Anderson, et al. (1991) found that evening types experienced a steady increase throughout the day in their speed of accessing information from long-term memory. However, the last testing time of the day in the study led by Anderson was 20:00 hours. The study led by Allen (2008) tested students between 8:00 and 10:00 AM (8:00 and 10:00 hours), 12:00 and 2:00 PM (12:00 and 14:00 hours), and again between 6:00 and 8:00 PM (18:00 to 20:00 hours). That study concluded that typical college students experienced their best performance at tasks testing executive functioning and processing speed during the afternoon and evening hours. However, neither Allen's (2008) study nor Anderson's (1991) study experiment beyond 20:00 hours. This is not a weakness for the previously mentioned studies because Anderson's (1991) study is meant to inform on TOD

effects and aging, and Allen's (2008) study was meant to inform start time for face-to-face college courses. For this present study, examining a larger range of time was necessary in order to adequately study TOD effects for asynchronous online learners who are given much broader parameters of time to take tests in their natural learning environment. While the present study does not involve repeated measures testing like those by Anderson (1991) and Allen (2008), these findings do suggest a decline in evening performance beyond 20:00 hours among students taking tests later in the day. The implication for these findings is specific to asynchronous online courses because while it is possible that face-to-face courses could be testing as late as 22:00 hours, it is unlikely.

The implication that any positive TOD effects may diminish by 22:00 hours is an important contribution to TOD research because it goes beyond the existing times tested in prior literature. By measuring time on a continuum, this study is specifically applicable to asynchronous online learning because it mirrors the way time is measured in those courses. Students taking Econ 2106 were allowed to take tests at any TOD as long as they met the deadlines for taking tests. This often meant that they took tests beyond 20:00 hours, which is where the literature on TOD leaves off. Prior to this present study, I was not able to find objective evidence on TOD effects in the evening beyond 20:00 hours. The negative correlation found in this study is objective evidence that these asynchronous online students who took tests between 16:01 and 22:00 hours could expect lower test scores the later they took tests during this time period. By providing evidence of TOD effects beyond 20:00 hours, this study expands the research on TOD effects. Further research to determine the point in time for which score decline can be expected is needed.

Implication #4

We can naturally assume that the cognitive complexity of an assessment will affect achievement, however we cannot ignore that TOD could play a comparable role when tests are taken in an asynchronous learning environment. This is relevant to student success in online learning because of the comparison to test complexity. While instructors may be able to advise students on optimal times to take tests, without imposing program control, the onus for heeding this advice is on the student. Comparing TOD effects with something that is widely assumed to affect achievement will make TOD effects more concrete for students, and may motivate them to choose time of testing more wisely.

Trockel, et al. (2000) conducted a health-related study on the variables affecting GPA for undergraduate students. They approach this study from the perspective of health promotion professionals, with the goal of improving health practices among students. What is interesting to note about this study is that the researchers sought to identify health-related variables, make students aware of the variables that were found to affect GPA, in an effort to motivate students to improve their health behaviors (Trockel, et al., 2000). It was the link to GPA, not improvement in their health that was thought to motivate students to change behaviors. Framing the recommendations in the context of GPA improvement were thought to place them in perspective for students thus motivating them to follow the advice.

The implication that TOD effects on test scores are comparable to test complexity's effect on those scores achieves the same goal for this study. Without imposing program control over the time students take tests, instructors teaching in asynchronous learning environments can provide learner support by advising students that certain TOD selections could negatively impact their cognitive ability, and hence their grade. Equating this impact to any effect test complexity

may have on their achievement could serve to put this idea into perspective for students and motivate them to adapt their test taking time accordingly. Schnackenberg and Sullivan (2000) say that due to the open nature of the World Wide Web that literal program control is no longer possible. However, Tennyson and Buttrey (1980) found that students benefit most from learner control when offered meaningful guidance. Any TOD recommendations that can be made from this study are made more meaningful to students by placing them into perspective.

The findings that TOD had a comparable effect on test scores to that of test complexity contributes to knowledge on TOD effects. I have found many studies that test specific cognitive competencies using abstract assessments, and reporting TOD effects on those specific competencies. However, I have not found research measuring the complexity of academic tests, which involve several cognitive competencies at the same time, and determining the variance in test achievement based on TOD and cognitive complexity. The results of this study will allow students to place TOD effects into relatable perspective, and provide online instructors advising students on TOD selection with an appropriate framework of comparison to motivate students to heed advice.

Implication #5

Variance attributable to TOD effect on asynchronous test scores could be converted to score impact. In the first part of this study, a hierarchical multiple regression was performed to determine how much variance in overall assessment scores TOD contributed when test complexity was controlled. This test analyzed scores for assessments taken between 16:01 to 22:00 hours for all students taking Econ 2106. The finding was that, TOD contributed 1.3% of the total variance in score between 16:01 and 22:00 hours, F change (1, 456) = 6.28, p = .013. The effect size

for this difference was significant, *beta* = -.116, *p* = .013. When analyzed using the standard deviation for the mean score on all tests taken in Econ 2106 between 16:01 and 22:00 hours (*M* = 73.26, *SD* = 16.90), the effect size was found to impact assessment scores by as much as -1.96 points. The effect size shows that, in this case, statistical significance is also practically significant because TOD could affect their grade.

When the smaller data sub-set was analyzed during the second part of this study for TOD's contribution to variance after controlling for individual differences using GPA, TOD was not found to be a significantly contributing factor to assessment score variance, *R* squared change = .087, *F* change (1,31) = 3.07, *p* = .09. Despite the 8.7% of variance attributed to TOD, the effect size still failed to show significance (*beta* = -.296, *p* = .09). However, the sample size used to run this hierarchical multiple regression was 34 once the sample was narrowed to include only tests taken during the significant TOD of 16:01 to 22:00 hours. I ran a sample size estimate using a medium effect size (f^2 = .15) to determine that at least 43 participants were needed in order to achieve adequate power of .80 with alpha level of .05. Therefore, even though the original sample for the small data sub-set fulfilled the sample size requirements determined prior to conducting this research, once the sample was reduced based on the results of statistical testing performed during the first part of the study using the large data set, the small data sub-set was insufficient to achieve adequate power on this multiple regression. Given the variance attributed to TOD in this test, it is suspected that results could be replicated using a larger data set and statistical significance could result. However, additional research is needed to achieve these results. Once statistical significance is achieved, converting variance into grade variation would be possible by comparing the beta value of the TOD variable with the standard deviation for the mean of all student scores on Final Exam Part I (*M* = 70.86, *SD* = 12.20).

The practical importance of score difference could influence students to adjust the times they take asynchronous online tests. Like the comparison between TOD effects and test complexity, the practical significance of TOD's impact on grades could motivate students to change their TOD selections when presented with this evidence. Since grades are the primary measure of success in online courses, advising students to change TOD selection by noting the possible impact on their grades helps to place the findings of this research into terms students can easily understand. In addition, since asynchronous online classes typically never meet face-to-face, grades may be the only type of performance feedback that students receive (Shim & Ryan, 2005). For students who are not intrinsically motivated to achieve content mastery, grades themselves can serve as extrinsic rewards. Likewise, lower grades can negatively affect motivation. Lee and Choi (2011) wrote a meta-analysis of literature on online course dropout rates. They cite multiple studies indicating that motivation was a significantly contributing factor to online students' decisions to drop out of online courses (Lee & Choi, 2011). Many studies attributed lack of motivation, in part, to low grades in online courses (Lee & Choi, 2011). The implication is that grades and motivation are linked to online course retention. If there are practical ways to guide students on achieving higher grades other than completing course content and studying for tests, instructors should take advantage of those tactics. Further, students should be made aware of the measures they can take to achieve success in practical terms that they can understand.

The implication of practical importance based on impact to student assessment scores contributes to the body of knowledge on TOD effects in that these results represent something new. While Callan (1999) does use academic measures to show TOD effects, he analyzes existing scores using ANOVA. The finding that TOD could affect assessment scores by as much as -1.96 points was determined using multiple regression which is a statistical tool that can be used

for making predictions based on existing variables. I have not found any research on TOD effects that provides specific predicted outcomes for academic measures.

Limitations

One limitation of this study is that in addition to TOD effects, confounding variables such as the number of hours students study for the test, the individual abilities of each student, etc. could affect the scores on the tests. To mitigate the results of confounding variables, test complexity and GPA were taken into consideration according to the variance they contribute. While these measures do not eliminate the threat of confounding variables to the validity of this study, they do address the concern. However, one limitation of the GPA data is that it was self-reported by participants. Accessing student GPA data is a violation of privacy laws therefore this limitation is unavoidable. Another limitation concerning the attempt to control for confounding variables involves the use of a panel of Ph.D. students who were not necessarily familiar with the Economics-related content to determine test complexity for instructor-created questions. The questions whose complexity was determined by the panel of Ph.D. raters only made up 3.7% of the total number of questions contained on these Econ 2106 tests. Additionally, 2 of the 5 questions rated by this panel instructed students to select the best matches. Match was one of the action verbs presented to this panel as an example of an RU competency. Of the remaining questions, 2 asked students to solve a problem given explicit variable names. This type of problem was presented to the panel as an anchor question exemplifying the EA category. The last question rated by this panel was the only question that did not easily fit into one of the categories based on obvious characteristics. This question represents less than 1% of the total questions composing the Econ 2106 tests for which complexity was determined and statistically controlled.

Another limitation of this study is that the deadlines for completing tests were set at 10:00 PM (22:00 hours) (Frost, 2015). Therefore, on the last day of the availability period, the time span for this study only included the hours between 0:00 and 22:00. This also means that there were no test scores from the 22:01 to 23:59 hour achievement period that were taken on the day of the test deadline. However, all tests for this course were available on the first day of the semester. There were suggested weeks to take each test, with deadlines set for the end of that week. Therefore theoretically, students could have taken all 10 tests during the first week of class, and besides the deadline days all other days during the test availability period include data from times spanning 0:00 to 23:59 hours. Despite this, the 10:00 PM deadline might have been a factor in the significance of the achievement pattern between 16:01 to 22:00 hours. For all tests given in Econ 2106, 70.4% were taken on the day of the deadline. Of those tests that were taken on the day of the deadline, 19.9% were completed between 21:00 and 22:00 hours. If the instructor had set the deadline later, perhaps the significant TOD would change. In addition, this may indicate that other factors such as procrastination may be at play besides TOD. Further quantitative and qualitative research would be needed to determine the role additional factors contribute to decreased performance on tests between 16:01 and 22:00 hours.

The 19.9% of scores on tests which were taken within 1 hour of the deadline may have also been affected by the testing environment. These 10:00 PM deadlines fell on Friday nights (22:00 hours) (Frost, 2015). This day and time may have made testing more difficult for these young adults. College students who have been in classes all week tend often use weekend evenings to relax and celebrate the end of the week. With no early classes to attend, they may celebrate into the late evening hours and early morning hours. The sounds of celebration could be distracting for students who live in dorms or even for students who live off campus with fellow

college students as roommates. By 10:00 PM on any given Friday, weekend celebration would be in full swing for college students. This confounding factor could have an effect on test scores for students who chose to test just before the deadline posted on the syllabus. Further research would be needed to rule this confounding variable out.

While time measurement for this study was based on a continuum, time for each day started at 0:00 hours and ended at 23:59 hours. This may have created an artificial distinction between times, but the choice to start time and end time at these points was made because U.S. military time establishes this precedent. It would be interesting to conduct future research including time as a continuum using different start times and end times in order to explore the relationship between TOD and achievement in asynchronous learning environments. Specifically, I would like to determine if there is a relationship between TOD and academic achievement during the late night hours; perhaps between 23:00 hours and 4:00 hours. However, that type of study would not be possible with the data used for this study because so few students took test during these times.

Previous research on the link between cognitive achievement and TOD have established that older adults experience higher achievement on cognitive tasks in the morning hours, while younger adults experience their highest level of achievement on cognitive tasks in the afternoon and evening hours (May, et. al 1993, Intons-Peterson et al. 1998). The age of participants in this study is not known; all that is known is that they are undergraduate students. However, the average age of undergraduate students at this institution is 24 (Georgia State University Office of Institutional Effectiveness, 2013-2014), but the risk of older student data skewing these results does exist. To mitigate this risk, future research studies should determine the age of participants contributing to the data.

Recommendations on optimal time of testing for asynchronous online students can only be made using the results of this study for evening types. Due to the low number of participants who categorized as morning MEQ types, a fully crossed model showing the synchrony effect could not be performed. No quantitative data exists indicating the synchrony effect for morning types, therefore objective conclusions for these MEQ types cannot be made using the results of this study. In addition, the use of neither MEQ types is problematic considering that Horne and Ostberg (1976) found that they can experience bimodal circadian peaks, which are decreased in amplitude when compared with those of morning and evening MEQ types. This is likely why previous research on the synchrony effect (Bennett, et al., 2008; Borella, et al., 2011; Intons-Peterson, 1998; May & Hasher, 1998; May, 1999) excluded neither MEQ types when testing the synchrony effect. Finally, since this study only tests TOD effects on asynchronous tests given in an online Economics class, more research would need to be conducted to determine if the results of this study are generalizable to other subjects.

Suggestions for Further Research

In addition to further quantitative research to confirm the generalizability and mitigate the limitations of these findings on TOD effects in asynchronous online courses, further quantitative, as well as qualitative research is needed to consider the role of procrastination in TOD selection and determine if maladaptive procrastination contributes to TOD effects. Steel (2007) wrote a meta-analysis of the procrastination literature. He cites studies stating that 80-95% of college students procrastinate, which is defined as "to voluntarily delay an intended course of action despite expecting to be worse off for the delay" (Steel, 2007, p. 66). Through my experience teaching online, I have anecdotally noticed that students wait until just before the deadline to take tests.

When gathering data for this study, in addition to the score and TOD tests were taken, I also recorded the mathematical distance the date the test was taken from its due date (see Appendix H). While procrastination was not the focus of this study, quantitative evidence did reveal that a majority of the test scores from this course were the result of students taking the tests on the day of the deadline; 19.9% of those were taken within one hour of the deadline. This is objective evidence that students were putting off taking tests, but the question of whether students were procrastinating cannot be answered from this data alone.

Schraw, Wadkins and Olafson (2007) describe two types of procrastination; adaptive and maladaptive. Adaptive procrastinators do so because they work better under pressure, and feel they are more focused when they have less time. Maladaptive procrastination arises out of laziness, fear of failure and a desire to postpone work. The study by Schraw, et al. concludes that maladaptive procrastination results in higher anxiety and lower achievement for students. I suspect a link between TOD effects in asynchronous online courses and the negative effects associated with maladaptive procrastination. However, the results of this study cannot be conclusively linked to procrastination because we do not know what motivated students to choose the time they took tests. Further mixed methods research is needed to replicate the quantitative results of this study and then explore the factors that play a role in the time students choose to take tests in asynchronous learning environments.

Summary

The intent of this study was to determine the relationship between TOD and academic achievement on multiple choice assessments given within asynchronous online courses. In addi-

tion, this study sought to replicate the synchrony effect in an asynchronous online setting. A significant linear relationship between TOD and academic achievement was determined within this study between the hours of 16:01 and 22:00. While scores on assessments for this course did peak around 16:00 hours, there was a negative correlation between TOD and achievement on assessments taken during this time. This means that the later students took tests for this course, the lower their scores were likely to be. Within this data set, TOD significantly contributed to the variance in assessment scores when test complexity was controlled. However, when a smaller sub-set of this data was examined, TOD did not contribute in a statistically significant way to assessment score variance when individual differences were controlled using GPA. Finally, evidence of the synchrony effect (the link between peak cognitive performance and peak circadian arousal period) (May & Hasher, 1998) was found upon examination of the smaller data sub-set. Although a fully crossed research design of MEQ type X TOD was not possible with this data set, significantly higher mean assessment scores for students identifying as evening MEQ types taking tests in the PM hours show that synchrony did exist for those students. While procrastination was not the focus of this study, a strong indication of procrastination among students was found within this data. However, further mixed methods research is suggested in order to come to any substantial conclusions on procrastination.

This research is meant to provide objective evidence that TOD effects for asynchronous online students should be considered. The results of this study can be used by online instructors and those advising online students to provide recommendations aimed at increasing student success. I do not advocate program control over the time students take tests. Instead, information on TOD effects and recommendations for success should be provided to students taking asynchronous online courses and students should choose whether to heed that advice. This study is

not meant to represent an over-arching reality on TOD effects within asynchronous online settings. Instead, further research replicating and expanding upon these results is needed before generalizations can be made. These results could provide objective data for future grounded study research utilizing both qualitative and quantitative data to examine TOD effects in asynchronous online settings.

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APPENDICES

Appendix A

CONSENT FORM
Georgia State University
Learning Technologies Division
College of Education
Informed Consent
Title: **Time of Day and Achievement in Asynchronous Learning Environments**

Principal Investigator: Steve W. Harmon, PhD

Student PI: Angela H. Gilleland

I. Purpose:

You are invited to take part in a research study. The purpose of the study is to determine if a correlation exists between time of day and achievement on assessments in an online learning environment. Another purpose of this study is to examine the factors contributing to the time of day you select to take online assessments, as well as reasons for an effect time of day might have on your achievement. You are invited to participate because you are currently taking an online course which allows you to take tests at any time of the day or night you choose as long as the test is complete by the deadline. Between 36 and 169 participants will be recruited for this study. Participation will require a total of 15 minutes of your time during the Fall, 2015 semester.

II. Procedures:

If you decide to participate, you will allow the researchers to use your answers to the online questionnaire as well as examine your test score for Part I of the Final Exam in Econ 2106 and the time of day you took that test. Beyond participating in the survey, we will not ask you to do any activities that are not part of your regular coursework.

III. Risks:

In this study, you will not have any more risks than you would in a normal day of life. The researchers for this study are not connected to the Economics Department, and will not be grading you in any way.

IV. Benefits:

Participating in the study may not benefit you directly. The result of this research will offer guidance to online students, as well as online instructors and instructional designers who are faced with setting deadlines and advising students on how to be successful when learning online.

V: Compensation:

Participants in this survey will earn 5 points of extra credit added to your Participation/Effort score for Econ 2106. If you choose not to participate, an alternate assignment is offered to you which will also earn 5 points of extra credit added to your Participation/Effort score for Econ 2106.

V. Voluntary Participation and Withdrawal:

Participation in this study is strictly voluntary. If you decide to be in the study and then change your mind, you will not lose any rights to which you are otherwise entitled. You have the right to drop out at any time; that decision will not affect your grade.

VI. Confidentiality:

We will keep your records private to the extent allowed by law. We will use a coding system, rather than your name on study records. Only the researchers in this study, as well as the Georgia State Institutional Review Board (IRB) and Office for Human Research Protections

(OHRP) will have access to the information you provide. All data will be stored in password protected files. You will be assigned a numeric identifier when you agree to participate, that identifier will be used to link any data collected about you. A separate file, not containing data, will be kept with names and identifiers. That file will be password protected, and destroyed once the research study concludes. This will make any connection between your name and any data collected about you impossible. Although we will make every effort to protect confidentiality, data sent over the Internet may not be secure. Your personal information will not appear when we present this study or publish its results, and you will not be identified personally.

VII. Contact Persons:

Contact Angela H. Gilleland at 404-944-3491 or agilleland1@student.gsu.edu if you have questions, concerns, or complaints about this study. You can also call Susan Vogtner in the Georgia State University Office of Research Integrity at 404-413-3513 if you think have been harmed by the study, if you have questions or concerns about your rights in this study, or if you want to talk to someone who is not part of the study team. Susan Vogtner can also be reached by email at svogtner1@gsu.edu.

VIII. Copy of Consent Form:

We will provide you with a copy of this consent form for your records. If you agree to participate in this research by sharing test scores, times of day taken, participating in the survey, please choose "Agree to Participate."

Appendix B

Survey:
TOD Selection and Achievement in Asynchronous Online Courses: Including the Morningness Eveningness Questionnaire (Horne and Ostberg, 1976)

Questions 1-19 are designed to determine your sleep-wake patterns. They are taken from:

Horne, J., & Ostberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *International Journal of Chrono-biologv*, 4, 97-110.

Please read each question carefully before answering. Both your answers and the results will be kept in strict confidence. Note that you will receive these questions one at a time, and you will not be allowed to go back to previous questions. Please try to answer all questions.

1. Considering only your own "feeling best" rhythm, at what time would you get up if you were entirely free to plan your day?
   1) Between 11:00 AM and 12:00 PM
   2) Between 9:45 AM and 11:00 AM
   3) Between 7:45 AM and 9:45 AM
   4) Between 6:30 AM and 7:45 AM
   5) Between 5:00 AM and 6:00 AM

2. Considering only your own "feeling best" rhythm, at what time would you go to bed if you were entirely free to plan your evening?
   1) Between 1:45 AM and 3:00 AM
   2) Between 12:30 AM and 1:45 AM
   3) Between 10:15 PM and 12:30 AM
   4) Between 9:00 PM and 10:15 PM
   5) Between 8:00 PM and 9:00 PM

3. If there is a specific time at which you have to get up in the morning, to what extent are you dependent on being woken up by an alarm clock?
   1) Very dependent
   2) Fairly dependent
   3) Slightly dependent
   4) Not at all dependent

4. Assuming adequate environmental conditions, how easy do you find getting up in the mornings?
   1) Not at all easy
   2) Not very easy
   3) Fairly easy
   4) Very easy

5. How alert do you feel during the first half hour after having woken in the mornings?
   1) Not at all alert
   2) Slightly alert
   3) Fairly alert
   4) Very alert

6. How is your appetite during the first half hour after having woken in the mornings?
   1) Very poor
   2) Fairly poor
   3) Fairly good
   4) Very good

7. During the first half-hour after having woken in the morning, how tired do you feel?
   1) Very tired
   2) Fairly tired
   3) Fairly refreshed
   4) Very refreshed

8. When you have no commitments the next day, at what time do you go to bed compared to your usual bedtime?
   1) More than two hour later
   2) 1-2 hours later
   3) Less than one hour later
   4) Seldom or never later

9. You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him is between 7 AM and 8 AM. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?
   1) Would find it very difficult
   2) Would find it difficult
   3) Would be in reasonable form
   4) Would be in good form

10. At what time in the evening do you feel tired and as a result in need of sleep?
    1) Between 2:00 AM and 3:00 AM
    2) Between 12:45 AM and 2:00 AM
    3) Between 10:15 PM and 12:45 AM
    4) Between 9:00 PM and 10:15 PM
    5) Between 8:00 PM and 9:00 PM

11. You wish to be at your peak performance for a test which you know is going to be mentally exhausting and lasting for two hours. You are entirely free to plan your day and considering only your own "feeling best" which one of the four testing times would you choose?
    1) 8:00 AM to 10:00 AM
    2) 11:00 AM to 1:00 PM
    3) 3:00 PM to 5:00 PM
    4) 7:00 PM to 9:00 PM

12. If you went to bed at 11:00 PM, at what level of tiredness would you be?
    1) Not at all tired
    2) A little tired
    3) Fairly tired
    4) Very tired

13. For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which one of the following events are you most likely to experience?
    1) Will not wake up until later than usual
    2) Will wake up at usual time but will fall asleep again
    3) Will wake up at usual time and will dose thereafter
    4) Will wake up at usual time and will not fall back to sleep

14. One night you have to remain awake between 4:00 AM and 6:00 AM in order to carry out a night watch. You have no commitments the next day. Which one of the following alternatives will suit you best?
    1) Would not go to bed until watch was over
    2) Would take a nap before and sleep after
    3) Would take a good sleep before and nap after
    4) Would take all sleep before watch

15. You have to do two hours of hard physical work. You are entirely free to plan your day and considering only your own "feeling best" rhythm which one of the following times would you choose?
    1) 7:00 PM to 9:00 PM
    2) 3:00 PM to 5:00 PM
    3) 11:00 AM to 1:00 PM
    4) 8:00 AM to 10:00 AM

16. You have decided to engage in hard physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him is between 10:00 PM and 11:00 PM. Bearing in mind nothing else but your own "feeling best" rhythm how well do you think you would perform?
    1) Would be in good form
    2) Would be in reasonable form
    3) Would find it difficult
    4) Would find it very difficult

17. Suppose that you can choose your own work hours. Assume that you worked a FIVE hour day (including breaks) and that your job was interesting and paid by results. Which five consecutive hours would you select?
    1) Midnight to 5:00 AM
    2) 4:00 AM to 9:00 AM
    3) 8:00 AM to 1:00 PM
    4) 9:00 AM to 2:00 PM
    5) 1:00 PM to 6:00 PM
    6) 5:00 PM to 10:00 PM

18. At what time of the day do you think that you reach your "feeling best" peak?
    1) Between 10:00 PM and 4:00 AM
    2) Between 5:00 AM and 8:00 AM
    3) Between 8:00 AM and 9:00 AM
    4) Between 9:00 AM and 5:00 PM
    5) Between 5:00 PM and 10:00 PM

19. One hears about "morning" and "evening" types of people. Which one of these types do you consider yourself to be?
    1) Definitely a "morning" type
    2) Rather more a "morning" than an "evening" type
    3) Rather more an "evening" than a "morning" type
    4) Definitely an "evening" type

For questions 21-27, you are asked to rate the frequency with which you engage in the behavior. Please read each question carefully before answering. Your answers will be kept in strict confidence. Please try to answer all questions.

		1= never	2 = Sometimes	3= often	4= Always
20	I put off taking tests for this online Economics course				
21	I procrastinate on taking tests in this course because I perform better under pressure				
22	I put off taking tests in this course because I am more productive if I have less time				
23	I procrastinate on taking tests for this course because I have other things I'd rather be doing				
24	I put off taking tests for this course because I have other responsibilities that need more of my attention				
25	I put off taking tests for this course because I have low motivation				
26	I procrastinate more on taking the tests in this course that cover more difficult topics				
27	I procrastinate on taking tests for this course because I'm afraid of failing				

Questions 28-31 are open-ended. Please read each question carefully before answering, and use as much detail as you can when answering. Your answers will be kept in strict confidence. Please try to answer all questions.

28. What is your current, numeric, cumulative GPA?
29. What factors play a role in the time of day you choose to take tests in this online Economics course?
30. How does procrastination factor into the time of day you choose to take tests in this online Economics course?
31. How does procrastination affect your achievement on the tests in this online Economics course?

Appendix C

Alternate Assignment

Instructions: To earn five (5) points which will be added to your Participation/Effort score for Econ 2106, write a two-page, double-space paper in 12-pt font on the prompt below.

Describe three (3) examples of things that you have learned in Econ 2106 that you will use once you have finished your degree and are in the workforce. Be sure to provide specific examples and explain your examples completely. You will earn points as follows:

Fully describe 3 examples	= 3 pts
Explain how you will use this information once you complete your degree	= 1 pt
Adherence to the directions for this assignment (length, font, etc.)	= 1 pt
	5 pts total

Appendix D

Horne, J., & Ostberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *International Journal of Chronobiologv*, 4, 97-110.

Upon consulting with Gwen Spratt, Associate Legal Advisor for Georgia State University's Legal Affairs Department, who specializes in Intellectual Property Law, it was determine that use of Horne & Ostberg's (1976) Morningness-Eveningness Questionnaire (MEQ) should be considered fair use. First, it will be used in an educational context to advance scholarship on TOD and circadian rhythms. It will be released online through the LMS to a finite subset of students who must log in to the LMS in order to use it. In addition, the survey will be available for a limited period of time. The MEQ will be cited within the survey itself, with complete bibliographic information. The MEQ is a published work which has been widely used and validated in research with no reference (that this researcher has found) to permission being obtained prior to use (Anderson, et al., 1991; Bennett, et al., 2008; Hasher, et al., 2002; Intons-Peterson, et al., 1998; Li, et al., 1998; May, 1999; May, et al., 1993; May & Hasher, 1998). A University System of Georgia Fair Use Checklist was completed with the result that factors weigh in favor of fair use.

Fair Use Checklist

Name: Angela H. Gilleland Date: 10-6-2015

Class or Project: Dissertation: Time of Day and Achievement in Asynchronous Learning Environment

Course and Term: Fall 2015 / Spring 2016

Title of Copyrighted Work: A Self-Assessment Questionnaire to Determine Morningness-Eveningness in Human Circadian Rhythms

Author and Publisher: Horne, J.A. ; Ostberg, O. - Gordon and Breach, Science Publishers, Ltd.

Portion(s) to be used (e.g., pages, timer counts): 19 questions, pgs. 100-103

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For more information regarding the fair use factors, please see the fair use sections of the Policy on the Use of Copyrighted Works in Education and Research for the University System of Georgia, which can be found on the web at http://www.usg.edu/copyright/.

Complete and retain a copy of this checklist for each "fair use" of a copyrighted work in order to establish a "reasonable and good faith" attempt at applying fair use should any dispute regarding such use arise.

Factor 1: Purpose and Character of the Use

Weighs in Favor of Fair Use	Weighs Against Fair Use
☑ Nonprofit Educational Institution	☐ Commercial activity, profit from use
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☑ Published work	☐ Unpublished work
☑ Factual/informational and educational in nature or nonfiction work	☐ Fiction or highly creative work (art, music, novels, films, plays, poetry)
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☐ Portion used is not central or significant to entire work as a whole	☑ Portion used is central to work or "heart of the work"
☑ Amount taken is narrowly tailored to accomplish a demonstrated, legitimate purpose in the course curriculum and must be narrowly tailored to accomplish that purpose	☐ Amount taken is more than necessary to accomplish a demonstrated, legitimate purpose in the course curriculum or is not narrowly tailored to accomplish a demonstrated legitimate purpose in the course curriculum
☑ Access limited to students enrolled in course for only the term of the course	☐ Access not limited
☑ Factor Weighs in Favor of Fair Use	☐ Factor Weighs Against Fair Use

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☑ Permission for digital excerpt is not readily available from publisher or Copyright Clearance Center at a reasonable price	☐ Permission for digital excerpt is readily available from publisher or Copyright Clearance Center at a reasonable price
☑ Decidedly small portion used	☐ Large portion or entire work used
☑ User owns lawfully acquired or purchased copy of original work	☐ User does not own lawfully acquired or purchased copy of original work
☐ Use stimulates market for original work	☐ Use impairs the market or potential market for original work
☑ Factor Weighs in Favor of Fair Use	☐ Factor Weighs Against Fair Use

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Appendix E

Justification for Waiver of Informed Consent

Protocol Title: Time of Day and Achievement in Asynchronous Learning Environments

Reference Number: 336040

Principal Investigator: Stephen W. Harmon, Ph.D.

Student Principal Investigator: Angela H. Gilleland

I request that this protocol be granted a waiver of informed consent for the large data set. These test scores and times of day taken will be collected anonymously, and no identifying information will be collected. The researchers for this study are not associated with the Economics Department, and do not know the students taking this course. Sharing these test scores and times will not adversely affect the rights and welfare of participants. This information will present no more than "minimal risk" of harm to subjects.

Appendix F

Recruitment Communication

To recruit for the smaller study, this announcement was sent through D2L/Brightspace to all students in both sections of Econ2106:

Want extra credit?

To participate, click on the "extra credit" module in the content browser to the left of this announcement. This opportunity will be available November 15-29 ONLY. Check it out TO-DAY!

The Extra Credit module consisted of an overview document, and a link to the survey as well as a link to the dropbox containing the alternate assignment.

Extra Credit Overview:

If you participate between November 15 and 29, 2015, you will have the opportunity to earn 5 extra credit points which will be added to your Participation/Effort score for this class. You may complete **ONE** extra credit activity:

1. You are invited to participate in a research study which will examine the relationship between the time of day you take tests, and your achievement on online tests. The research study will also examine time of day selection as well as sleep/wake patterns to point to possible reasons for any relationship between time of day and achievement on online tests. Participation in this research study will take about 20 minutes of your time and will involve your release of grade-related information, and completion of an online survey. To read the consent and complete the survey, click the "Extra Credit Survey" link from the Extra Credit Module for this course.

OR

2. If you still want to earn extra credit, but don't want to participate in the research study, you can write a 2-page essay explaining how you will use information learned in this course once you are out in the workforce. Details about this assignment can be found in the "Extra Credit Essay" dropbox link within the Extra Credit Module for this course.

Either assignment you choose to complete will make you eligible to earn 5 extra credit points which will be added to your Participation/Effort score for this class. This extra credit activity must be complete by November 29 at 11:59 PM.

Appendix G

Parental Permission Document
Georgia State University
Learning Technologies Division
College of Education
Informed Consent

Title: **Time of Day and Achievement in Asynchronous Learning Environments**

Principal Investigator: Steve W. Harmon, PhD

Student PI: Angela H. Gilleland

I. Purpose:

Your minor student is invited to take part in a research study. The purpose of the study is to determine if a correlation exists between time of day and achievement on assessments in an online learning environment. Another purpose of this study is to examine the factors contributing to the time of day you select to take online assessments, as well as reasons for an effect time of day might have on your achievement. Your minor student is invited to participate because they are currently taking an online course which allows them to take tests at any time of the day or night they choose as long as the test is complete by the deadline. Between 36 and 169 participants will be recruited for this study. Participation will require a total of 15 minutes of your student's time during the fall, 2015 semester.

II. Procedures:

If you decide for your student to participate, you will allow the researchers to use their answers to an online questionnaire as well as examine their test score for Part I of the Final Exam in Econ 2106 and the time of day they took that test. Beyond participating in the survey, we will not ask your student to do any activities that are not part of their regular coursework.

III. Risks:

In this study, your student will not have any more risks than they would in a normal day of life. The researchers for this study are not connected to the Economics Department, and will not be grading your student in any way.

IV. Benefits:

Participating in the study may not benefit your student directly. The result of this research will offer guidance to online students, as well as online instructors and instructional designers who are faced with setting deadlines and advising students on how to be successful when learning online.

V: Compensation:

Participants in this survey will earn 5 points of extra credit added to their Participation/Effort score for Econ 2106. If you choose for your student not to participate, an alternate assignment is offered to which will also earn 5 points of extra credit added to their Participation/Effort score for Econ 2106.

V. Voluntary Participation and Withdrawal:

Participation in this study is strictly voluntary. If you decide for your student to be in the study and then change your mind, you will not lose any rights to which you are otherwise entitled. You have the right to drop out at any time; that decision will not affect your student's grade.

VI. Confidentiality:

We will keep your student's records private to the extent allowed by law. We will use a coding system, rather than your student's name on study records. Only the researchers in this study, as well as the Georgia State Institutional Review Board (IRB) and Office for Human Research Protections (OHRP) will have access to the information your student provides. All data will be stored in password protected files. Your student will be assigned a numeric identifier

when you agree to for them to participate, that identifier will be used to link any data collected about them. A separate file, not containing data, will be kept with names and identifiers. That file will be password protected, and destroyed once the research study concludes. This will make any connection between your student's name and any data collected about them impossible. Although we will make every effort to protect confidentiality, data sent over the Internet may not be secure. Your student's personal information will not appear when we present this study or publish its results, and your student will not be identified personally.

VII. Contact Persons:

Contact Angela H. Gilleland at 404-944-3491 or agilleland1@student.gsu.edu if you have questions, concerns, or complaints about this study. You can also call Susan Vogtner in the Georgia State University Office of Research Integrity at 404-413-3513 if you think have been harmed by the study, if you have questions or concerns about your rights in this study, or if you want to talk to someone who is not part of the study team. Susan Vogtner can also be reached by email at svogtner1@gsu.edu.

VIII. Copy of Consent Form:

We will provide you with a copy of this consent form for your records. If you agree for your student to participate in this research by sharing test scores, times of day taken, and participating in the survey, please sign below.

_____	_____
Parent or legal guardian name (Please print)	Parent or legal guardian Signature Date

Student name (Please print)	Principal Investigator Date or researcher obtaining consent

Appendix H

Large Data Set

Grade	TOD	Complexity	Date
60.00	19.33	1.48	-36.00
87.00	18.29	1.48	-34.00
100.00	23.13	1.33	-29.00
89.00	10.48	1.33	-23.00
77.00	14.54	1.48	-23.00
80.00	18.12	1.53	-23.00
90.00	22.55	1.60	-22.00
70.00	21.31	1.80	-21.00
77.00	11.00	1.53	-19.00
83.00	11.03	1.53	-18.00
77.00	19.20	1.48	-18.00
90.00	23.53	1.60	-18.00
100.00	2.54	1.40	-17.00
90.00	16.32	1.40	-17.00
100.00	17.29	1.60	-17.00
47.00	20.01	1.48	-17.00
70.00	8.14	1.20	-16.00
100.00	11.17	1.44	-16.00
61.00	12.30	1.44	-16.00
80.00	14.27	1.46	-16.00
100.00	16.47	1.46	-16.00
100.00	19.04	1.40	-15.00
70.00	19.18	1.44	-15.00
90.00	21.03	1.60	-14.00
80.00	13.00	1.44	-13.00
70.00	13.10	1.60	-13.00
80.00	17.42	1.46	-13.00
80.00	16.49	1.46	-11.00
40.00	23.23	1.20	-11.00
90.00	2.17	1.46	-10.00
90.00	12.12	1.46	-10.00
90.00	12.16	1.40	-10.00
50.00	12.20	1.80	-10.00
70.00	21.19	1.46	-10.00
80.00	1.10	1.40	-9.00
56.00	12.10	1.44	-9.00
97.00	15.24	1.53	-9.00
70.00	20.15	1.80	-9.00

70.00	23.13	1.44	-9.00
89.00	13.01	1.33	-8.00
90.00	14.07	1.44	-8.00
80.00	14.31	1.40	-7.00
77.00	14.37	1.53	-7.00
89.00	15.44	1.33	-7.00
80.00	16.24	1.20	-7.00
50.00	16.32	1.20	-7.00
90.00	16.57	1.60	-7.00
93.00	19.59	1.53	-7.00
50.00	20.38	1.40	-7.00
87.00	10.53	1.53	-6.00
70.00	12.47	1.40	-6.00
80.00	18.48	1.53	-6.00
80.00	23.07	1.46	-6.00
87.00	13.02	1.48	-5.00
90.00	16.05	1.44	-5.00
70.00	17.42	1.48	-5.00
67.00	21.35	1.48	-5.00
68.00	22.16	1.48	-5.00
80.00	23.18	1.80	-5.00
50.00	9.53	1.80	-4.00
77.00	11.03	1.53	-4.00
83.00	12.37	1.53	-4.00
100.00	14.31	1.46	-4.00
70.00	14.42	1.46	-4.00
100.00	16.06	1.20	-4.00
50.00	16.16	1.80	-4.00
90.00	16.27	1.46	-4.00
77.00	17.28	1.53	-4.00
80.00	18.11	1.44	-4.00
70.00	19.35	1.46	-4.00
80.00	20.00	1.46	-4.00
100.00	9.36	1.80	-3.00
70.00	11.22	1.80	-3.00
80.00	13.15	1.48	-3.00
89.00	13.46	1.33	-3.00
71.00	13.52	1.44	-3.00
90.00	14.10	1.80	-3.00
70.00	14.26	1.53	-3.00
100.00	16.03	1.44	-3.00
90.00	16.43	1.80	-3.00
30.00	17.13	1.40	-3.00

71.00	17.55	1.44	-3.00
80.00	18.31	1.20	-3.00
60.00	18.51	1.60	-3.00
90.00	18.52	1.60	-3.00
90.00	19.03	1.46	-3.00
75.00	19.13	1.48	-3.00
81.00	20.18	1.44	-3.00
75.00	23.22	1.44	-3.00
80.00	2.02	1.44	-2.00
60.00	10.45	1.44	-2.00
78.00	13.23	1.33	-2.00
100.00	13.28	1.46	-2.00
87.00	15.59	1.48	-2.00
87.00	16.39	1.48	-2.00
70.00	16.43	1.20	-2.00
100.00	18.16	1.44	-2.00
100.00	18.36	1.33	-2.00
80.00	19.05	1.44	-2.00
56.00	19.15	1.44	-2.00
80.00	19.39	1.44	-2.00
77.00	20.00	1.48	-2.00
81.00	20.45	1.44	-2.00
70.00	21.23	1.80	-2.00
50.00	21.34	1.80	-2.00
77.00	22.19	1.48	-2.00
100.00	22.20	1.33	-2.00
100.00	23.46	1.46	-2.00
83.00	0.04	1.48	-1.00
70.00	0.06	1.53	-1.00
87.00	1.22	1.53	-1.00
50.00	9.38	1.46	-1.00
70.00	9.47	1.44	-1.00
60.00	9.55	1.40	-1.00
90.00	10.17	1.46	-1.00
60.00	10.22	1.46	-1.00
55.00	10.29	1.44	-1.00
80.00	10.31	1.44	-1.00
40.00	10.31	1.44	-1.00
90.00	11.00	1.53	-1.00
90.00	11.38	1.46	-1.00
80.00	11.40	1.48	-1.00
100.00	12.47	1.60	-1.00
50.00	12.53	1.80	-1.00

90.00	13.31	1.60	-1.00
77.00	14.35	1.48	-1.00
91.00	14.51	1.44	-1.00
90.00	14.56	1.40	-1.00
40.00	15.00	1.80	-1.00
100.00	15.11	1.46	-1.00
89.00	15.28	1.33	-1.00
90.00	15.29	1.46	-1.00
30.00	16.18	1.80	-1.00
60.00	16.18	1.40	-1.00
60.00	16.23	1.44	-1.00
100.00	16.26	1.33	-1.00
70.00	17.12	1.20	-1.00
90.00	18.01	1.20	-1.00
60.00	18.06	1.53	-1.00
43.00	18.14	1.44	-1.00
90.00	18.15	1.40	-1.00
70.00	18.16	1.40	-1.00
60.00	18.16	1.53	-1.00
93.00	18.16	1.53	-1.00
60.00	18.31	1.44	-1.00
100.00	18.36	1.44	-1.00
90.00	18.37	1.46	-1.00
100.00	18.37	1.46	-1.00
90.00	18.45	1.60	-1.00
40.00	18.47	1.20	-1.00
50.00	18.51	1.20	-1.00
50.00	19.03	1.40	-1.00
70.00	19.04	1.44	-1.00
90.00	19.10	1.44	-1.00
77.00	19.11	1.53	-1.00
67.00	19.12	1.53	-1.00
90.00	19.21	1.20	-1.00
90.00	19.40	1.53	-1.00
70.00	19.41	1.46	-1.00
80.00	19.41	1.44	-1.00
100.00	19.51	1.44	-1.00
60.00	20.10	1.44	-1.00
73.00	20.38	1.48	-1.00
80.00	20.46	1.44	-1.00
80.00	21.05	1.44	-1.00
80.00	21.14	1.46	-1.00
90.00	21.24	1.46	-1.00

72.00	21.27	1.48	-1.00
87.00	21.30	1.44	-1.00
80.00	21.33	1.20	-1.00
70.00	21.46	1.40	-1.00
80.00	21.49	1.40	-1.00
100.00	21.52	1.44	-1.00
80.00	21.57	1.46	-1.00
83.00	21.57	1.53	-1.00
90.00	22.01	1.53	-1.00
60.00	22.07	1.20	-1.00
67.00	22.09	1.33	-1.00
90.00	22.26	1.44	-1.00
89.00	22.33	1.33	-1.00
97.00	22.38	1.53	-1.00
80.00	22.46	1.48	-1.00
80.00	22.49	1.48	-1.00
80.00	22.54	1.40	-1.00
80.00	22.58	1.40	-1.00
40.00	23.09	1.80	-1.00
80.00	23.15	1.44	-1.00
50.00	23.15	1.20	-1.00
100.00	23.16	1.46	-1.00
90.00	23.21	1.44	-1.00
80.00	23.21	1.44	-1.00
61.00	23.27	1.44	-1.00
70.00	23.30	1.80	-1.00
83.00	23.35	1.53	-1.00
70.00	23.47	1.40	-1.00
90.00	23.59	1.44	-1.00
77.00	0.09	1.48	0.00
80.00	0.48	1.40	0.00
60.00	0.55	1.46	0.00
90.00	1.06	1.53	0.00
30.00	1.12	1.80	0.00
70.00	1.52	1.48	0.00
80.00	2.10	1.44	0.00
60.00	2.24	1.60	0.00
60.00	2.39	1.60	0.00
89.00	2.47	1.33	0.00
96.00	5.31	1.44	0.00
71.00	6.58	1.44	0.00
90.00	7.18	1.60	0.00
91.00	8.15	1.44	0.00

100.00	8.57	1.44	0.00
80.00	9.44	1.44	0.00
91.00	10.31	1.44	0.00
50.00	10.33	1.44	0.00
80.00	10.36	1.44	0.00
80.00	10.59	1.44	0.00
80.00	11.04	1.80	0.00
100.00	11.23	1.33	0.00
90.00	11.26	1.20	0.00
60.00	11.27	1.60	0.00
70.00	11.51	1.20	0.00
40.00	11.55	1.80	0.00
50.00	12.03	1.20	0.00
77.00	12.23	1.48	0.00
78.00	12.28	1.33	0.00
90.00	12.30	1.44	0.00
70.00	12.37	1.80	0.00
70.00	12.37	1.40	0.00
70.00	12.45	1.44	0.00
70.00	12.49	1.80	0.00
50.00	12.51	1.20	0.00
80.00	12.54	1.20	0.00
70.00	12.57	1.44	0.00
93.00	12.57	1.53	0.00
80.00	13.00	1.44	0.00
73.00	13.02	1.53	0.00
89.00	13.06	1.33	0.00
60.00	13.08	1.20	0.00
70.00	13.08	1.60	0.00
60.00	13.14	1.40	0.00
70.00	13.16	1.80	0.00
90.00	13.18	1.80	0.00
67.00	13.23	1.33	0.00
90.00	13.27	1.80	0.00
70.00	13.27	1.60	0.00
80.00	13.33	1.60	0.00
60.00	13.35	1.46	0.00
90.00	13.35	1.20	0.00
100.00	13.36	1.44	0.00
70.00	13.39	1.40	0.00
77.00	13.55	1.53	0.00
90.00	14.01	1.46	0.00
80.00	14.01	1.44	0.00

60.00	14.02	1.40	0.00
50.00	14.02	1.60	0.00
100.00	14.06	1.20	0.00
70.00	14.08	1.46	0.00
90.00	14.13	1.46	0.00
100.00	14.13	1.80	0.00
70.00	14.15	1.53	0.00
60.00	14.17	1.40	0.00
80.00	14.24	1.44	0.00
78.00	14.24	1.33	0.00
60.00	14.25	1.80	0.00
80.00	14.30	1.80	0.00
56.00	14.30	1.33	0.00
47.00	14.34	1.44	0.00
80.00	14.34	1.60	0.00
73.00	14.34	1.48	0.00
90.00	14.37	1.46	0.00
70.00	14.40	1.46	0.00
50.00	14.40	1.20	0.00
100.00	14.43	1.44	0.00
70.00	14.43	1.44	0.00
78.00	14.49	1.33	0.00
80.00	14.50	1.53	0.00
90.00	14.56	1.44	0.00
100.00	15.05	1.60	0.00
90.00	15.06	1.60	0.00
89.00	15.06	1.33	0.00
80.00	15.09	1.40	0.00
40.00	15.10	1.80	0.00
60.00	15.12	1.40	0.00
70.00	15.13	1.20	0.00
89.00	15.14	1.33	0.00
80.00	15.15	1.40	0.00
40.00	15.17	1.40	0.00
100.00	15.18	1.40	0.00
80.00	15.22	1.44	0.00
81.00	15.25	1.44	0.00
63.00	15.26	1.44	0.00
60.00	15.26	1.20	0.00
63.00	15.27	1.48	0.00
47.00	15.28	1.44	0.00
60.00	15.30	1.80	0.00
90.00	15.30	1.40	0.00

90.00	15.31	1.46	0.00
100.00	15.31	1.60	0.00
90.00	15.32	1.48	0.00
50.00	15.35	1.20	0.00
50.00	15.37	1.60	0.00
80.00	15.40	1.44	0.00
90.00	15.43	1.60	0.00
79.00	15.48	1.48	0.00
37.00	15.50	1.53	0.00
71.00	15.51	1.44	0.00
71.00	15.55	1.44	0.00
100.00	15.57	1.44	0.00
11.00	15.57	1.33	0.00
70.00	15.58	1.40	0.00
100.00	16.00	1.46	0.00
50.00	16.04	1.80	0.00
50.00	16.06	1.53	0.00
44.00	16.07	1.44	0.00
100.00	16.14	1.40	0.00
56.00	16.16	1.33	0.00
80.00	16.17	1.48	0.00
100.00	16.19	1.44	0.00
63.00	16.22	1.44	0.00
100.00	16.24	1.46	0.00
100.00	16.29	1.60	0.00
65.00	16.31	1.44	0.00
70.00	16.34	1.44	0.00
83.00	16.35	1.53	0.00
90.00	16.37	1.60	0.00
80.00	16.41	1.46	0.00
65.00	16.44	1.44	0.00
90.00	16.44	1.80	0.00
70.00	16.46	1.46	0.00
90.00	16.47	1.53	0.00
50.00	16.49	1.40	0.00
70.00	16.51	1.80	0.00
83.00	16.54	1.48	0.00
63.00	16.55	1.44	0.00
90.00	16.56	1.60	0.00
80.00	17.00	1.46	0.00
89.00	17.01	1.33	0.00
90.00	17.03	1.46	0.00
77.00	17.03	1.53	0.00

100.00	17.04	1.60	0.00
60.00	17.05	1.44	0.00
70.00	17.05	1.20	0.00
75.00	17.06	1.48	0.00
80.00	17.07	1.40	0.00
90.00	17.08	1.46	0.00
100.00	17.09	1.60	0.00
90.00	17.11	1.60	0.00
80.00	17.13	1.60	0.00
70.00	17.15	1.46	0.00
50.00	17.15	1.20	0.00
67.00	17.15	1.33	0.00
91.00	17.16	1.44	0.00
57.00	17.16	1.44	0.00
90.00	17.16	1.60	0.00
40.00	17.18	1.80	0.00
90.00	17.18	1.40	0.00
88.00	17.20	1.48	0.00
56.00	17.24	1.44	0.00
70.00	17.27	1.44	0.00
80.00	17.29	1.44	0.00
70.00	17.30	1.44	0.00
80.00	17.32	1.44	0.00
70.00	17.33	1.48	0.00
80.00	17.35	1.46	0.00
100.00	17.36	1.60	0.00
53.00	17.36	1.53	0.00
90.00	17.37	1.46	0.00
47.00	17.37	1.48	0.00
67.00	17.44	1.33	0.00
100.00	17.45	1.53	0.00
70.00	17.46	1.40	0.00
50.00	17.50	1.20	0.00
73.00	17.51	1.48	0.00
80.00	17.53	1.46	0.00
78.00	17.55	1.33	0.00
70.00	17.57	1.46	0.00
100.00	17.57	1.33	0.00
100.00	17.59	1.44	0.00
80.00	18.00	1.53	0.00
93.00	18.00	1.53	0.00
70.00	18.07	1.46	0.00
70.00	18.09	1.20	0.00

70.00	18.12	1.20	0.00
40.00	18.13	1.46	0.00
56.00	18.13	1.44	0.00
100.00	18.13	1.33	0.00
74.00	18.16	1.48	0.00
70.00	18.17	1.60	0.00
90.00	18.18	1.80	0.00
33.00	18.18	1.33	0.00
70.00	18.18	1.48	0.00
60.00	18.22	1.40	0.00
90.00	18.23	1.44	0.00
80.00	18.23	1.80	0.00
100.00	18.23	1.33	0.00
57.00	18.26	1.44	0.00
93.00	18.27	1.53	0.00
61.00	18.28	1.44	0.00
30.00	18.28	1.80	0.00
78.00	18.28	1.33	0.00
61.00	18.29	1.48	0.00
80.00	18.30	1.60	0.00
70.00	18.33	1.40	0.00
80.00	18.33	1.60	0.00
80.00	18.36	1.48	0.00
70.00	18.38	1.46	0.00
90.00	18.39	1.44	0.00
57.00	18.39	1.53	0.00
43.00	18.41	1.53	0.00
70.00	18.42	1.20	0.00
100.00	18.44	1.44	0.00
90.00	18.48	1.46	0.00
78.00	18.48	1.33	0.00
60.00	18.49	1.80	0.00
60.00	18.50	1.80	0.00
80.00	18.52	1.46	0.00
78.00	18.54	1.33	0.00
67.00	18.54	1.48	0.00
78.00	18.59	1.33	0.00
56.00	19.03	1.33	0.00
70.00	19.04	1.40	0.00
80.00	19.05	1.40	0.00
78.00	19.05	1.33	0.00
78.00	19.07	1.33	0.00
78.00	19.08	1.33	0.00

50.00	19.09	1.60	0.00
70.00	19.09	1.53	0.00
70.00	19.13	1.44	0.00
60.00	19.14	1.60	0.00
93.00	19.14	1.48	0.00
77.00	19.15	1.33	0.00
70.00	19.16	1.60	0.00
90.00	19.17	1.46	0.00
90.00	19.17	1.46	0.00
80.00	19.17	1.44	0.00
60.00	19.18	1.40	0.00
93.00	19.19	1.44	0.00
77.00	19.20	1.48	0.00
93.00	19.20	1.53	0.00
70.00	19.22	1.80	0.00
53.00	19.23	1.53	0.00
73.00	19.24	1.44	0.00
85.00	19.24	1.44	0.00
89.00	19.24	1.33	0.00
80.00	19.25	1.20	0.00
80.00	19.26	1.44	0.00
90.00	19.28	1.60	0.00
80.00	19.30	1.46	0.00
90.00	19.30	1.44	0.00
40.00	19.32	1.44	0.00
60.00	19.32	1.80	0.00
90.00	19.32	1.20	0.00
70.00	19.34	1.80	0.00
90.00	19.38	1.46	0.00
90.00	19.39	1.53	0.00
90.00	19.40	1.44	0.00
80.00	19.40	1.40	0.00
60.00	19.41	1.80	0.00
70.00	19.41	1.40	0.00
53.00	19.41	1.48	0.00
80.00	19.43	1.46	0.00
80.00	19.43	1.60	0.00
70.00	19.44	1.53	0.00
63.00	19.45	1.44	0.00
90.00	19.47	1.46	0.00
40.00	19.47	1.80	0.00
63.00	19.47	1.48	0.00
77.00	19.50	1.48	0.00

70.00	19.54	1.80	0.00
83.00	19.54	1.53	0.00
90.00	19.55	1.20	0.00
100.00	19.55	1.33	0.00
30.00	19.56	1.80	0.00
90.00	19.57	1.60	0.00
80.00	19.58	1.44	0.00
80.00	19.59	1.46	0.00
65.00	20.01	1.48	0.00
78.00	20.09	1.33	0.00
81.00	20.09	1.48	0.00
43.00	20.09	1.48	0.00
70.00	20.10	1.20	0.00
100.00	20.10	1.40	0.00
90.00	20.11	1.40	0.00
80.00	20.12	1.46	0.00
50.00	20.12	1.80	0.00
80.00	20.12	1.40	0.00
70.00	20.13	1.60	0.00
80.00	20.15	1.20	0.00
70.00	20.15	1.40	0.00
80.00	20.15	1.60	0.00
78.00	20.15	1.33	0.00
55.00	20.15	1.48	0.00
47.00	20.16	1.44	0.00
70.00	20.19	1.20	0.00
70.00	20.20	1.60	0.00
100.00	20.20	1.60	0.00
80.00	20.20	1.48	0.00
80.00	20.22	1.46	0.00
100.00	20.22	1.44	0.00
78.00	20.22	1.33	0.00
80.00	20.22	1.53	0.00
73.00	20.22	1.53	0.00
70.00	20.23	1.20	0.00
70.00	20.24	1.20	0.00
100.00	20.24	1.20	0.00
80.00	20.24	1.40	0.00
60.00	20.25	1.48	0.00
53.00	20.27	1.44	0.00
80.00	20.29	1.60	0.00
90.00	20.30	1.20	0.00
90.00	20.30	1.53	0.00

80.00	20.31	1.60	0.00
70.00	20.32	1.20	0.00
60.00	20.35	1.46	0.00
60.00	20.35	1.20	0.00
73.00	20.36	1.48	0.00
80.00	20.37	1.40	0.00
73.00	20.37	1.48	0.00
90.00	20.38	1.46	0.00
50.00	20.39	1.46	0.00
39.00	20.39	1.48	0.00
90.00	20.40	1.44	0.00
40.00	20.41	1.80	0.00
50.00	20.41	1.20	0.00
70.00	20.42	1.80	0.00
90.00	20.43	1.46	0.00
30.00	20.45	1.20	0.00
78.00	20.45	1.33	0.00
80.00	20.46	1.44	0.00
70.00	20.46	1.40	0.00
100.00	20.46	1.33	0.00
70.00	20.47	1.20	0.00
70.00	20.47	1.20	0.00
90.00	20.48	1.60	0.00
50.00	20.49	1.40	0.00
60.00	20.50	1.60	0.00
60.00	20.51	1.46	0.00
100.00	20.52	1.40	0.00
70.00	20.52	1.40	0.00
80.00	20.53	1.44	0.00
90.00	20.53	1.60	0.00
60.00	20.55	1.44	0.00
60.00	20.55	1.20	0.00
80.00	20.55	1.60	0.00
60.00	20.55	1.60	0.00
70.00	20.56	1.20	0.00
66.00	20.57	1.44	0.00
40.00	20.58	1.44	0.00
20.00	20.58	1.80	0.00
50.00	20.58	1.20	0.00
63.00	20.58	1.53	0.00
37.00	21.00	1.44	0.00
60.00	21.01	1.44	0.00
70.00	21.02	1.20	0.00

80.00	21.03	1.60	0.00
60.00	21.05	1.46	0.00
100.00	21.05	1.80	0.00
90.00	21.05	1.20	0.00
64.00	21.05	1.48	0.00
46.00	21.06	1.44	0.00
100.00	21.06	1.80	0.00
56.00	21.06	1.48	0.00
90.00	21.07	1.40	0.00
30.00	21.08	1.60	0.00
83.00	21.08	1.53	0.00
87.00	21.08	1.53	0.00
80.00	21.10	1.40	0.00
50.00	21.10	1.60	0.00
70.00	21.12	1.80	0.00
80.00	21.12	1.20	0.00
60.00	21.12	1.20	0.00
60.00	21.13	1.80	0.00
90.00	21.14	1.46	0.00
60.00	21.14	1.80	0.00
67.00	21.14	1.33	0.00
70.00	21.15	1.80	0.00
80.00	21.17	1.44	0.00
60.00	21.20	1.40	0.00
90.00	21.20	1.40	0.00
93.00	21.20	1.53	0.00
78.00	21.21	1.33	0.00
73.00	21.21	1.53	0.00
66.00	21.22	1.44	0.00
83.00	21.22	1.48	0.00
60.00	21.23	1.44	0.00
56.00	21.23	1.33	0.00
100.00	21.23	1.33	0.00
70.00	21.23	1.53	0.00
80.00	21.24	1.80	0.00
78.00	21.24	1.33	0.00
83.00	21.24	1.53	0.00
50.00	21.25	1.80	0.00
60.00	21.25	1.20	0.00
80.00	21.25	1.20	0.00
50.00	21.26	1.80	0.00
90.00	21.27	1.20	0.00
100.00	21.27	1.60	0.00

80.00	21.28	1.60	0.00
58.00	21.28	1.48	0.00
63.00	21.28	1.48	0.00
80.00	21.29	1.44	0.00
27.00	21.30	1.44	0.00
70.00	21.30	1.40	0.00
50.00	21.30	1.40	0.00
56.00	21.30	1.33	0.00
63.00	21.30	1.53	0.00
80.00	21.31	1.44	0.00
50.00	21.31	1.80	0.00
50.00	21.32	1.60	0.00
40.00	21.33	1.20	0.00
48.00	21.34	1.44	0.00
80.00	21.34	1.40	0.00
30.00	21.35	1.80	0.00
90.00	21.35	1.20	0.00
70.00	21.35	1.40	0.00
60.00	21.35	1.40	0.00
40.00	21.36	1.80	0.00
100.00	21.36	1.60	0.00
89.00	21.36	1.33	0.00
87.00	21.36	1.53	0.00
80.00	21.37	1.44	0.00
60.00	21.37	1.80	0.00
70.00	21.38	1.44	0.00
100.00	21.38	1.60	0.00
60.00	21.39	1.20	0.00
70.00	21.39	1.20	0.00
50.00	21.39	1.40	0.00
90.00	21.39	1.60	0.00
78.00	21.39	1.33	0.00
90.00	21.39	1.53	0.00
50.00	21.42	1.40	0.00
67.00	21.42	1.33	0.00
100.00	21.43	1.33	0.00
70.00	21.43	1.48	0.00
57.00	21.43	1.53	0.00
70.00	21.44	1.80	0.00
70.00	21.44	1.80	0.00
67.00	21.44	1.48	0.00
56.00	21.45	1.33	0.00
67.00	21.45	1.33	0.00

77.00	21.46	1.48	0.00
90.00	21.46	1.53	0.00
60.00	21.47	1.60	0.00
97.00	21.47	1.53	0.00
87.00	21.49	1.48	0.00
80.00	21.50	1.53	0.00
80.00	21.51	1.44	0.00
63.00	21.51	1.48	0.00
80.00	21.52	1.20	0.00
78.00	21.52	1.33	0.00
70.00	21.53	1.80	0.00
100.00	21.53	1.60	0.00
70.00	21.54	1.60	0.00
73.00	21.54	1.48	0.00
57.00	21.54	1.53	0.00
70.00	21.55	1.20	0.00
90.00	21.55	1.40	0.00
80.00	21.55	1.60	0.00
50.00	21.56	1.44	0.00
47.00	21.56	1.44	0.00
100.00	21.56	1.60	0.00
89.00	21.57	1.33	0.00
50.00	21.58	1.44	0.00
53.00	21.58	1.53	0.00
40.00	21.59	1.80	0.00
70.00	21.59	1.60	0.00
67.00	21.59	1.33	0.00
67.00	21.59	1.48	0.00
46.00	21.59	1.48	0.00
67.00	22.00	1.44	0.00
60.00	22.00	1.48	0.00
56.00	22.01	1.33	0.00
70.00	22.02	1.20	0.00
70.00	22.02	1.20	0.00
57.00	22.04	1.48	0.00
90.00	20.54	1.60	1.00
43.00	19.30	1.48	2.00
50.00	12.36	1.80	3.00
80.00	12.40	1.80	3.00
50.00	16.23	1.60	3.00

Appendix I

Small Data Sub-set

ID	SmFE1Grade	SmFE1TOD	SmFE1Date	MEQScore	GPA
11129	43	19.30	2.00		2.70
21115	73	20.37	0.00	48	4.01
31115	77	12.23	0.00	39	4.00
41117	60	19.33	-36.00	58	3.90
51117	75	19.13	-3.00	46	2.86
61115	83	0.04	-1.00	41	3.55
71118	73	20.36	0.00	39	3.70
81119	53	19.41	0.00	53	2.50
91129	93	19.14	0.00	36	2.80
101116	63	21.47	0.00		3.40
111129	70	1.52	0.00	42	2.30
121115	77	20.00	-2.00	64	3.39
131115	70	17.42	-5.00	42	3.68
141115	70	17.33	0.00	60	2.56
151115	67	18.54	0.00	50	3.24
161115	73	11.54	0.00	58	3.36
171116	77	19.20	0.00	32	3.10
181116	77	14.54	-23.00	45	2.04
191119	80	22.46	-1.00	39	2.57
201116	88	17.20	0.00	39	2.95
211115	68	11.16	-5.00	33	3.07
221118	74	18.16	0.00	39	3.60
231116	47	20.01	-18.00	50	2.63
241117	58	21.28	0.00	35	2.63
251116	80	18.36	0.00	36	2.60
261117	77	19.50	0.00	34	3.02
271116	47	17.37	0.00	45	3.11
281116	87	15.59	-2.00	47	2.90
291129	73	14.34	0.00	42	
301126	79	15.48	0.00	51	2.75
311129	70	21.43	0.00	61	3.12
321115	67	21.35	-5.00	46	3.88
341121	77	19.20	-19.00	46	2.92
351129	63	21.28	0.00	34	2.00
361115	90	15.32	0.00	41	3.49
371129	67	21.44	0.00	46	
381129	73	20.38	-1.00	50	3.00
391116	80	16.17	0.00	32	3.20

401115	61	18.29	0.00	46	2.89
411116	63	15.27	0.00	40	2.50
421122	63	21.51	0.00	44	2.56
431115	83	16.54	0.00	37	3.50
441129	60	20.25	0.00	23	3.84
451119	72	21.27	-1.00	50	3.83
461115	80	22.49	-1.00	60	2.65
471115	57	22.04	0.00	57	2.60
481129	81	20.09	0.00	33	
491116	46	21.59	0.00	44	3.12
501129	55	20.15	0.00		2.50
511115	77	22.19	-2.00	48	3.06
521115	77	21.46	0.00	56	2.77
541117	80	11.40	-1.00	39	3.20