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1. INTRODUCTION

It is commonly believed that homework is an important component of students' education because it allows independent practice of concepts encountered in class. Smolira (2008) asserts that the goals of homework are to enhance student knowledge, improve retention, and to encourage students to master the concepts at the time they are taught. As research suggests, however, these benefits may not be realized. Whether homework is beneficial to student outcomes is not always conclusive, and the reasons given are varied (see Cooper, Robinson, & Patall, 2006, and Trautwein & Koller, 2003, for reviews).

Smolira (2008) suggests that whether homework is beneficial may be a factor of feedback timing. He points out that graded homework typically isn't returned to the student until at least the next class meeting, which delays feedback to the student. By then, the class likely has moved on to another topic reducing the usefulness of the feedback for learning. He suggests that online homework may provide a solution to this problem, as online homework programs provide instant feedback. Online homework is a component of e-learning, defined as learning and/or teaching that is promoted online through network technologies (Garrison & Anderson, 2003). Using a sample of 50 undergraduate and 30 graduate finance students, Smolira (2008) found support for his contention that online homework may solve the feedback problem of traditional (paper-and-pencil) homework. All students in this sample were required to complete their homework using an online homework program that used end-of-chapter textbook questions in online format. At the end of the semester, students were surveyed about their opinions concerning their experiences with the homework program. The majority of the students (68% of undergraduates and 73% of graduate students) reported experiencing longer study time, leading to 46% of undergraduates and 77% of graduate students reporting that they felt better prepared for their exams. Also, 64% of the undergraduates felt that online homework was more beneficial for them than traditional homework, and 70% of the graduate students agreed. The author suggests that these benefits may have been due to the immediate feedback component in online homework, and that this component can make the difference for students' learning.

Feedback is defined by Hattie & Timperley (2007) as the information given to the performer concerning his/her performance, or in simpler terms the "consequence" of that performance. These authors maintain that for feedback to be useful it must be timely and have a learning component. When students are given information about the process for solving a problem, they are then armed with tools they can use the next time a similar problem is faced. Likewise, when they are given information about the effectiveness of their own self-regulation efforts, their self-regulation skills are more likely to improve and self-efficacy for that task increases. Feedback that strictly focuses on whether student answers are correct, as well as feedback about the student personally, are not viewed as useful for increasing students' mastery nor their self-efficacy for the task at hand (Hattie & Timperley, 2007).

Research supports the importance of feedback in the effectiveness of homework. According to Clariana, Wagner, and Roher Murphy (2000), the benefits of feedback timing depend on the type of items being tested. These authors found that with easier items (i.e. those requiring lower-level processing), immediate feedback was most effective for students' learning. As the difficulty level increased, some delay appeared to be more useful. For delayed feedback, the effect size for easy items was only -0.06, indicating the delayed feedback had no benefit. For more difficult items, the effect size was 0.35 for intermediate difficulty and 1.17 for the most difficult items. These results were similar to those provided by Kulik & Kulik (1988) whose meta-analysis found that immediate feedback is better for students when involved in processing material (such as during class activities), with an effect size of 0.28, but when performing tasks such as a test, delayed feedback is more useful with an effect size of 0.36 for the delay. According to these meta-analyses, it appears that immediate feedback may be most useful for students when practicing material for mastery, i.e. when completing homework, and less useful when being tested. If this is the case, then the immediate feedback feature of most online homework programs could prove beneficial to student outcomes.

2. ONLINE HOMEWORK VERSUS TRADITIONAL HOMEWORK

Research on the benefits of online homework versus traditional homework is mixed and varied. Some find that online homework has better outcome results for students than traditional homework (Brewer & Becker, 2010; Dufresne, Mestre, Hart, & Rath, 2002; Ogilve, 2000; Smolira, 2008) while others find there is no difference in student performance (Bonham, Deardorff, & Beichner, 2003; Cutshall, Mollick, & Bland, 2009; Demirci, 2007; Kodippili & Senaratne, 2008; Palocsay & Stevens, 2008). To illustrate, Brewer & Becker (2010) describe the assignment of homework to 145 undergraduate algebra students, with 85 students completing the assignments through traditional paper-pencil and 60 students completing their work through an online homework program. Their goals were to determine whether online homework could improve students' learning beyond that of traditional homework as measured by final exam scores, and whether online homework could allow significant improvement for poorly prepared and repeat students. No significant difference between the two groups in terms of final exam scores were found, but upon comparison of the poorly prepared and repeat students in the two treatment conditions the authors found that those in the online homework group fared significantly better on the final exam than did those in the traditional homework group ($t = -2.174$, $p = 0.033$, $d = 0.526$). Though the authors were expecting enhanced learning due to the immediate feedback and multiple attempts allowed by the online program, it appears that this feature increases learning only for those students who are ill-prepared for college algebra. Students who were prepared for the course apparently may not benefit.

In a study with similar goals, but with different results, Dufresne, et. al. (2002) compared the merits of web-based homework over traditional homework. These authors were interested in whether web-based (online) homework could significantly improve learning over that of traditional (paper-and-pencil) homework among students in general, as well as between high and low ability students, and high and low achieving students. Additionally, they sought to learn whether students spent more time engaged in either form of homework, reasoning that more time spent may increase learning. Over the span of seven semesters and using approximately 1400 undergraduate students each semester, the authors compared gain scores (mean final exam scores for the web-based homework group minus the mean final exam scores for the traditional homework group) and found that four of the five instructors' students showed gain scores of 4.9

to 9.7 points, while the fifth showed a negative gain of -2.2. Taken together, the authors indicate this finding is not significant but that when considered separately the web-based homework group significantly outperformed the traditional homework group for the first four instructors, but not for the fifth. No significant differences were found between high and low ability, nor high and low achieving, students between the two homework conditions. Finally, only the students in one of the instructors' sections were asked to provide information about time spent on homework. The majority of those completing web-based homework reported spending greater than 4 hours per week on homework (46.2%), while the majority (62.1%) of the traditional homework group reported spending less than two hours. This suggests that time spent on homework made no difference in student outcomes. The authors acknowledge that since their study was "ex post facto", no precautions were taken to ensure that homework content between the two delivery methods were comparable, nor were any measures taken to ensure that students were exposed to similar lecture and testing conditions across course instructors. This method may be useful in exploring what occurs in a non-manipulated natural setting, yet there is room for many errors making it difficult to determine effect. One important concern is that without careful attempts to equalize the groups on influencing variables, results obtained may well be due to chance.

In a more varied study, Ogilvie (2000) investigated the benefits for student outcome in a calculus-based mechanics course on a variety of course components, two of which were traditional homework and web-based homework. Gain scores for the 60 students from pretest to posttest on the Forced Concept Inventory indicate that web-based homework benefitted students at a higher rate than that of traditional homework (3.7% gain versus a 1.7% gain). The author contends that interactive web-based homework is twice as effective for students' conceptual understanding as traditional homework, and attribute this effect to the interactive nature of the web-based assignment wherein students could choose alternate problems and received instant grading of their work. Though there was no control condition in this study (i.e. no separate group using each method for homework), the comparison of the students' own performance under each homework condition suggests some benefits of the web-based homework.

Though some have found online homework to be beneficial to student grades, others have reached different conclusions. For example, Bonham, Deardorff , and Beichner (2003) examined whether online homework would benefit students by increasing their understanding and problem-solving skills, as measured by exam grades, and found that other factors were better predictors of these variables than homework delivery method. Over the span of two semesters, one section was assigned traditional paper-pencil homework while the other was assigned web-based online homework. For the first semester (a calculus-based physics class), 117 students completed online homework and 113 completed paper-pencil homework, while in the second semester (an algebra-based physics class) 64 students experienced the online homework and 56 students experienced paper-pencil homework. Students in each section were not told which method of homework delivery they would receive until the first day of class, and were then allowed to switch sections if they chose to do so. No students reported changing sections. The web-based homework was automatically graded by computer and the paper-pencil homework was graded by a graduate student teaching assistant. Students were also required to attend a 2-hour lab each week separate from their lecture classes. At the end of the study, the authors found that although homework delivery method made no difference in students' exam grades in the first semester, homework averages were different for the two groups ($t = 4.13$, $p = 0.000$) in the calculus-based class with the online homework average ($\bar{x} = 87.9$) surpassing the paper-pencil homework average ($\bar{x} = 72.7$). The authors attribute this difference to the fact that online homework allows for multiple attempts at correctness for each problem, whereas students submitting paper homework get only one chance at correctness. For the second semester algebra-based class, homework grades did not differ between groups, but exam scores did ($t = 2.35$, $p = 0.02$). The online homework group scored higher on exams ($\bar{x} = 82.4$) than did the paper-pencil homework group ($\bar{x} = 77.3$), and the authors believed this difference was due to the influence of GPA and SAT math scores which were stronger predictors of test grades. This led the authors to conclude that although test scores were significantly different for the two groups, the insignificant predictor of homework delivery method did not account for the difference. It is interesting to note, however, that the significant difference found between homework conditions in the first semester do indicate some potential benefit to students' understanding, at least in homework exercises.

Other studies have shown similar results. For instance, Palocsay and Stevens (2008) investigated the value of homework delivery method in a sample of 327 business statistics students. In this sample, 27 students completed traditional homework assignments, and the other 300 were assigned to three different types of online homework. The authors found that type of homework experienced by students made no difference in their final exam scores, but that instructor experience and GPA were instead predictive of the students' exam scores. In another study, Kodippili & Senaratne (2008) implemented a similar process to explore the effectiveness of online homework on undergraduate students' final grades in an algebra course. In their sample of 72 students, 34 students completed online homework assignments while 38 students completed traditional homework. These authors found that there was no significant difference in grades regardless of homework method, but acknowledge that a greater percentage of "successful grades" (70% for the online group vs. 49% for the traditional group) was earned by the online homework students. Although these two studies showed no significant benefit for online homework, the trend appears to be that online homework may be beneficial for some students under some conditions.

Results of previous research indicate that whether online homework is superior to traditional homework, at least in regards to student grades, is still questionable. However, the application of online homework has distinct advantages such as allowing the assignment of ample practice work for students while reducing the grading load for instructors. Other advantages, such as providing alternate problems, multiple attempts, and immediate feedback for students, make the further study of its usefulness worthwhile. Additionally, the available literature repeatedly measures what is essentially the same student outcomes, namely, that of grades. Other outcomes that factor into student learning may also be impacted by the features of online homework, and should therefore be explored.

2.1 Online Homework in Statistics

Homework is viewed as a necessity in statistics courses because the focus is on developing quantitative problem-solving skills, and the needed practice for skill development cannot be completed during the typical three-hour-per-week class session. Palocsay & Stevens (2008) point out that most statistics instructors spend class time demonstrating calculations and explaining analyses outcomes, and the practice element of completing work outside of class is important for students to be able to build their own skills.

Cutshall, et. al. (2009) acknowledge the importance of homework to assist statistics students in building their skills, but point out that the necessary time involved in grading and providing constructive feedback for students can become a problem for instructors. The consequence becomes either lessening the number of homework problems assigned, or sacrificing the quality of feedback for students. Cutshall and colleagues (2009) suggest that online homework applications can remedy this situation because it provides students with plenty of skill practice along with immediate feedback. One increasingly popular online homework source is Aplia. Aplia was originally developed as an online homework program for college economic students in 2002, but has since been used in the fields of accounting, business statistics, and most recently, educational statistics. The program provides online homework questions that include conceptual problems as well as interactive graphs and tables. The publisher of Aplia, Cengage, claims that the application will “help students face their fear of math, show them how to correctly interpret statistical data, and make sure that they grasp the skills and concepts presented in their textbooks”. Whether an online program can help alleviate fears has yet to be investigated, but Aplia does include the benefit of providing immediate feedback on student effort. The program’s “grade it now” feature allows students three opportunities to succeed at each problem, and the publisher states that as many as 83% of students that use this feature improve their score (Aplia, Cengage, 2002). As scores increase, it can be assumed that statistical skills are also increasing. This claim is in line with the conclusions reached by Kluger and DeNisi (1996) whose review of literature yielded the conclusion that feedback is effective as long as it enhances self-efficacy and promotes more effective self-regulation in a way that causes students to put more effort into the task. Along with this immediate feedback, the program also includes a drop-down box labeled “explanation” that provides a description of how to solve the problem correctly. In this way, the feedback is taking on an instructional aspect, rather than merely a correctional one, which is believed to increase students’ learning (Hattie & Timplerley, 2007). Additionally, having the choice to attempt each homework problem up to three times may give students some sense of control over their homework experience, thereby increasing their self-efficacy. As Bandura (1997, p.140-141) suggests, when students perceive some control over their situation, anxiety is reduced and efficacy is increased.

2.2 Statistics Anxiety and Self-Efficacy

If it is true that the Aplia online homework program can “help students face their fear”, then one of its benefits may be in alleviating some of the anxiety that is so common to students in statistic courses. Statistics anxiety has been defined as a type of performance anxiety characterized by worry, intrusive thoughts, tension, and physiological symptoms that occur when students are exposed to situations where statistical problem-solving and evaluation is present (Zeidner, 1991). Others have defined the construct similarly as “a feeling of anxiety when taking a statistics course or doing statistical analysis; that is gathering, processing, and interpreting data” (Cruise, Cash, & Bolton,1985), or anxiety that results from engaging in statistics in any form or level (Onwuegbuzie, DaRos, & Ryan, 1997). However defined, research shows that statistics anxiety can have crippling effects on students who experience it (see Onwuegbuzie & Wilson, 2003, for review). Statistics anxiety has been shown to effect students' grades in both statistics and research classes (Bell, 2003; Lalonde & Gardner, 1993; Onwuegbuzie, 2000; Onwuegbuzie & Seaman, 1995; Zanakis & Valenzi1997; Zeidner, 1991). To illustrate, Zeidner (1991) showed statistics anxiety to be related to student performance. Using scores of 431 students, the author found that students reporting higher anxiety also scored lower at course end (r = -0.128). These students also believed they possessed lower ability (r = -0.37), reflecting lower levels of self-efficacy.

Bandudra (1997) defines self-efficacy as students' beliefs in their own capabilities to produce desired outcomes. In terms of self-efficacy for statistics, students with higher self-efficacy would believe themselves capable of learning and/or performing to desired standards in statistics classes. Though self-efficacy has been indirectly studied in connection with statistics anxiety, earlier studies (e.g. Bandalos, Yates, & Thorndike-Christ, 1995; Benson 1989) typically employed general self-efficacy instruments to measure statistics self-efficacy instead of a measure specific to the tasks involved in statistics courses. As Finney & Schraw (2003) explain, using a general self-efficacy measure instead of one that is specific to the task being measured may indicate little or no relationship with outcome. Therefore, Finney & Schraw (2003) developed two measures of statistics self-efficacy: the Self-Efficacy for Learning Statistics (SELS) and the Current Statistics Self-Efficacy (CSSE) scale. In a sample of 103 undergraduate students, the authors subsequently found that self-efficacy measured at the end of the course was significantly positively related to course grades (r = 0.496) and significantly negatively related to statistics test anxiety (r = -0.572). These findings indicate that when students feel less anxiety, their belief in their own abilities increase allowing a greater understanding of statistical concepts which is then demonstrated by higher grades. This was an important breakthrough because it encourages educators to consider student aspects other than grades that contribute to course outcomes.

In a more recent study investigating statistics anxiety and self-efficacy, Perepiczka, Chandler, and Becerra (2011) used Finney & Schraw's (2003) instruments and found evidence of the relationship between statistics anxiety and self-efficacy in a sample of 166 graduate students. Through an online survey, participants were asked about their statistics anxiety, attitude toward statistics, perceived levels of social support, and self-efficacy for statistics. The authors found that attitude toward statistics, statistics anxiety, and social support accounted for 52.8% of the variance in self-efficacy for statistics. They conclude that as individual predictors, only statistics anxiety and attitude were significant predictors of self-efficacy with anxiety accounting for 3% of variance and attitude accounting for 7% of the variance in self-efficacy. These results add additional support to the link between students' self-efficacy and statistics anxiety, and provide justification for further investigations.

Though sparse, research suggests that a reduction in statistics anxiety may be accompanied by an increase in statistics self-efficacy and, as Bandura (1997, p. 216) contends, students with greater self-efficacy are more likely to demonstrate better learning. Bandera (1997, p. 216) explains that as students acquire cognitive skills, their academic self-efficacy tends to increase, and their performance increases as well. Therefore if an online homework program, such as Aplia, can help students "face their fear" then it would follow that their self-efficacy and therefore their grades may also be affected.

Previous research on this topic demonstrates two problems. The first is in the conceptualization of homework delivery method as the explanation for student outcomes. Whether homework is completed online or by traditional paper-and-pencil is not the issue. Delivery method alone has yet to explain why some students do appear to benefit from online homework and others do not (e.g. Brewer & Becker, 2010). It is instead feedback timing that is at issue with homework delivery, with method of delivery (online or traditional) functioning only as the mechanism by which we present students with either immediate or delayed feedback.

The second problem is the repeated use of grades as the main outcome variable. Since many things can affect student grades (e.g. instructor experience in Palocsay and Stevens' (2008) study, or statistics anxiety and self-efficacy in Zeidner's (1991) study), perhaps a measurement of other outcomes that are known to be related to student grades may help clarify whether online homework is truly superior for students' learning. This study seeks to explore two of these other variables, and how they may be related to the feedback timing of homework. Specifically, if immediate feedback is capable of enhancing student efficacy and therefore reducing anxiety better than that of delayed feedback, then online homework can be expected to affect students' self-efficacy and anxiety concerning statistics. If these are affected, then we can expect to see the effect on grades. Therefore, the null hypotheses addressed in this study will include:

1) Feedback timing will not affect students' levels of statistics anxiety.
2) Feedback timing will not affect students' statistics self-efficacy.
3) Feedback timing will not affect students' homework, test, or final grades.

3. METHODS

3.1 Participants

During the 2010-2011 academic year, four sections of graduate-level introductory educational statistics courses in a large Southwestern university were invited to participate in the current study. All sections were taught by the same instructor, and all students agreed to participate. The sample of 71 (n = 71) volunteers consisted of 30 (42.3%) male and 41 (57.7%) female students with a mean age of 29.9 ($\bar{x}$= 29.90, SD = 9.75) years. Forty-five (63.4%) were white, 16 (22.5%) were Asian, 7 (9.9%) were Hispanic, 2 (2.8%) were African American, and 1 (1.4%) reported his/her ethnicity as "other". Forty-five (63.4%) were masters students and 26 (36.6%) were doctoral students. The majority of the students (93.9%) were more than half way through their degree programs, with 74.2% having less than 30 hours remaining. Though students were not specifically asked to indicate their majors, enrollment records indicate that the fields of educational psychology, sports psychology, higher education, counseling, hospitality administration, nutritional science, mass communications, and family/consumer science were represented.

Prior to the beginning of the study, the four sections were randomly assigned to differing homework conditions: either online homework, which represented the immediate feedback condition, or traditional paper-and-pencil homework, which represented the delayed feedback condition. Two of the sections (fall 2010, n = 21, and summer 2011, n = 15) completed homework assignments using the Aplia online homework program, and two of the sections (both in spring 2011, total $n = 35$) completed homework using the traditional paper-pencil method. All other course elements (syllabus, topics, format, exams) were identical for the four sections.

3.2 Instruments and Procedure

On the first day of classes, students were given a pre-test questionnaire addressing demographic information, statistics self-efficacy, and statistics anxiety. The purpose of the pretest was to gain a baseline for self-efficacy and for statistics anxiety before any instruction in statistics was delivered. Statistics self-efficacy was measured using the Self-Efficacy to Learn Statistics (SELS) scale (Finney & Schraw, 2003). The SELS consists of 14 items designed to measure students' confidence in their ability to learn the necessary skills for completing common statistical problems. Directions for completion indicate that the student should answer according to his/her ability to learn statistical skills (i.e. "Please rate your confidence in *learning* the skills necessary while you are in this class to successfully complete the following tasks"). Sample items include "Identify if a distribution is skewed when given the values of three measures of central tendency", and "Explain what the numeric value of the standard error is measuring". The scale is scored on a 6 point Likert scale from 1 (no confidence at all) to 6 (complete confidence) and an overall self-efficacy for learning statistics score is computed by obtaining a total score across all items. Therefore, possible scores range from 14 to 84, with scores closer to 84 indicating higher levels of confidence for learning statistical skills. In the current study, Cronbach's reliability coefficient for the SELS scale was 0.97.

Statistics anxiety at pre-test was measured using the Statistics Anxiety Rating Scale (STARS) (Cruise, Cash, & Bolton, 1985), which consists of 51 items measured on a 5 point Likert-scale. The instrument includes six sub-scales, or factors, designed to assess anxiety in the areas of worth of statistics, interpretation anxiety, test and class anxiety, computation self-concept, fear of asking for help, and fear of statistics teachers. Worth of statistics refers to students' perceptions of the usefulness of statistics either in their personal, academic, or future professional lives. Sample items include "I feel statistics is a waste" and "I'm never going to use statistics so why should I have to take it?", and are scored along the continuum of 1 (strongly disagree) to 5 (strongly agree). Interpretation anxiety refers to how much anxiety students may feel when faced with having to interpret statistical data, or make a decision about an analysis outcome, and are scored from 1 (no anxiety) to 5 (high anxiety). Sample items reflecting this type of anxiety include "Trying to decide which analysis is appropriate for your research project" and "Interpreting the meaning of a probability value once I have found it". Test and class anxiety are measured on the same scale, with items such as "Doing the homework for a statistics course" and "Going over a final examination in statistics after it has been graded". Computation self-concept represents students' anxiety over computing math problems as well as their self-perceptions of mathematical ability. Sample items from this subscale, measured on a 5-point Likert scale from strongly disagree to strongly agree, include "I haven't had math in a long time. I know I'll have problems getting through statistics" and "I could enjoy statistics if it weren't so mathematical". The final two subscales, also measured on a 5-point Likert scale with 1 indicating no anxiety and 5 indicating high anxiety, are designed to assess students' fear of asking for help in understanding statistics material, and students' fear of statistics teachers. Sample items include "Asking someone in the computer center for help in understanding a printout" and "Statistics teachers are so abstract they seem inhuman." Higher scores on each of the subscales indicate higher anxiety levels for that area. For the current study, Cronbach's reliability coefficients for the six subscales were 0.93 (worth of statistics), 0.87 (interpretation anxiety), 0.95 (test and class anxiety), 0.84 (computation self-concept), 0.93 (fear of asking for help), and 0.78 (fear of statistics teachers).

Near the last day of classes, students were given a follow-up questionnaire consisting of measurements to address the students' post-instruction levels of statistics self-efficacy and statistics anxiety. Post-instruction self-efficacy was assessed with the Current Statistics Self-Efficacy (CSSE) scale (Finney & Schraw, 2003). The CSSE consists of the same 14 items used in the SELS, but with the instructions for completion worded to reflect current ability (i.e. "Please rate your confidence in your *current ability* to successfully complete the following tasks"). Cronbach's alpha for the CSSE was 0.96. Post-instruction statistics anxiety was measured with the STARS, and reliability coefficients for the six subscales were 0.95 (worth of statistics), 0.90 (interpretation anxiety, 0.95 (test and class anxiety), 0.86 (computation self-concept), 0.90 (fear of asking for help), and 0.85 (fear of statistics teachers).

Throughout each semester, grades were collected on 6 homework assignments. At the end of the semester, homework grades were averaged together after dropping the lowest grade, and accounted for 25% of students' final grade. Homework assignments covered the topics of 1) frequency distributions and percentiles; 2) central tendency, variability, probability, and the normal curve; 3) correlation and simple regression; 4) z-tests and t-tests; 5) one way ANOVA; and 6) chi-square analysis. Being mindful of the findings presented by Clariana, et. al (2000), which indicated that students benefitted from immediate feedback most often when study questions were of the lower to mid-level type, only these types of homework questions were selected for inclusion in this study. Additionally, great care was taken to ensure that the number, type, and difficulty level of homework questions presented to the online homework group were as similar as possible to those presented to the traditional homework group. For example, a sample online-homework question included in the assignment for central tendency and variability was "A sociologist interested in youth culture is conducting research. To determine how many songs high-school age iTunes users typically download in a week, she obtains a sample of N=9 high-school students. Students are asked how many songs they typically download in a week. Their responses are shown below. Calculate the mean, median, and mode of the sample". The corresponding traditional homework question was "One question on a student survey asks: In a typical week, how many times do you eat at a fast food restaurant? The following table summarizes the results for a sample of n = 20 students. Find the mode, the median, and the mean". Similarly, for the online homework assignment covering z-tests and t-tests, one of the questions was "You should use the t statistic if the population standard deviation is ____". The corresponding traditional homework question for this assignment was "Under what circumstances is a t statistic used instead of a z-score for a hypothesis test? ____".

Grades were also collected on 3 tests covering 1) frequency distributions, percentiles, central tendency, and variability; 2) probability, normal curve, correlation, regression, and z-tests; and 3) t-tests, one way ANOVA, and chi-square. Tests consisted of between 30 and 35 multiple choice items stressing conceptual performance, and 10 to 15 items stressing computational performance. All 3 exams were given to all students in both conditions in paper-and-pencil format, and each exam accounted for 25% of the students' final grade. Total possible points for the course was 100 points.

4. RESULTS

Both the fall 2010 section and the summer 2011 section used the Aplia online homework program, and constitute the experimental group. The control group consisted of two sections of spring semester graduate students, both of which occurred weekly for 14 weeks. Since the summer section occurred daily for four weeks, and the fall section occurred weekly for 14 weeks, it is possible that this difference may influence students' self-efficacy and anxiety regardless of the homework method employed. Therefore, before any analysis using the independent variable of feedback timing, one-way multiple analysis of variance (MANOVA) were conducted to check for differences between these two sections in self-efficacy and statistics anxiety at both pre- and post-test. Results of the MANOVA indicate no significant differences, either at pretest ($\lambda = 0.772$, $F\,(7, 28) = 1.18$, $p = 0.35$) or posttest ($\lambda = 0.852$, $F\,(7, 28) = 0.696$, $p = 0.68$) between the two sections in regards to self-efficacy or statistics anxiety. Therefore, the fall and summer sections were assumed to be identical with regards to the dependent variables and their data was therefore combined to create one experimental group.

Descriptive data were obtained prior to analysis, and are presented in Tables 1, 2 and 3. Table 1 depicts the intercorrelations among dependent variables for the online homework group, while Table 2 shows the same correlations for the traditional homework group. Although the large number of correlations may lead some researchers to apply an adjustment (e.g. Bonferroni) to avoid increasing the family wise Type I error rate, Perneger (1998) advises against this procedure because of the resulting increase in Type II error. Due to this concern, and the likelihood that significant relationships between variables will be discounted, the Bonferroni adjustment was not performed for these correlations. As Perneger (1998) recommends, the significance of very low r values should be interpreted with caution. As indicated, all six types of statistics anxiety were significantly and negatively related to statistics self-efficacy in the online group, while three types of statistics anxiety were significantly negatively related to statistics self-efficacy in the traditional group, indicating that as students' anxiety decreased, their self efficacy increased. Grades, however, do not show a relationship with either of these variables for either group. Table 3 provides the means and standard deviations, by group, for the students' homework, test, and final grades.

Table 1: Pearson's *r* correlations among dependent variables for online homework group

	WS	IA	TCA	CSC	FAH	FST	CSSE	T1	T2	T3	HW	FG
WS	-	0.42**	0.42**	0.52**	0.37*	0.58**	-0.55**	-0.15	0.14	-0.07	-0.10	-0.07
IA		-	0.71**	0.63**	0.69**	0.29	-0.49**	-0.06	-0.01	-0.07	-0.29	-0.12
TCA			-	0.53**	0.62**	0.15	-0.50**	-0.10	0.18	0.04	-0.13	0.00
CSC				-	0.68**	0.55**	-0.66**	-0.09	0.21	-0.01	0.03	0.04
FAH					-	0.43**	-0.56**	-0.06	0.14	0.02	-0.18	-0.02
FST						-	-0.53**	-0.15	0.07	-0.19	-0.11	-0.13
CSSE							-	0.12	0.01	-0.04	0.17	0.06
T1								-	0.56**	0.79**	0.24	0.83**
T2									-	0.65**	0.53**	0.83**
T3										-	0.40*	0.91**
HW											-	0.63**

Note: WS: Worth of Statistics; IA: Interpretation Anxiety; TCA: Test and Class Anxiety; CSC: Computation Self-Concept; FAH: Fear of Asking for Help; FST: Fear of Statistics Teacher; CSSE: Current Statistics Self Efficacy; T1: Test 1; T2: Test 2; T3: Test 3; HW: Homework Average; FG: Final Grade

*$p \leq 0.05$; **$p \leq 0.01$

Table 2: Pearson's *r* correlations among dependent variables for traditional homework group

	WS	IA	TCA	CSC	FAH	FST	CSSE	T1	T2	T3	HW	FG
WS	-	0.52**	0.44**	0.70**	0.39*	0.54**	-0.46**	-0.27	-0.18	-0.01	0.13	-0.10
IA		-	0.56**	0.26	0.73**	0.44**	-0.19	-0.27	-0.38*	-0.14	-0.23	-0.32
TCA			-	0.36*	0.45**	0.46**	-0.44**	-0.08	-0.28	-0.09	-0.27	-0.21
CSC				-	0.20	0.43*	-0.42*	0.02	-0.02	-0.06	0.08	-0.02
FAH					-	0.35*	-0.15	-0.09	-0.29	0.10	0.09	-0.07
FST						-	-0.27	0.17	0.00	0.10	0.11	0.11
CSSE							-	0.01	0.06	0.21	0.09	0.14
T1								-	0.33	0.42*	0.21	0.63**
T2									-	0.53**	0.44**	0.78**
T3										-	0.65**	0.89**
HW											-	0.71**

Note: WS: Worth of Statistics; IA: Interpretation Anxiety; TCA: Test and Class Anxiety; CSC: Computation Self-Concept; FAH: Fear of Asking for Help; FST: Fear of Statistics Teacher; CSSE: Current Statistics Self Efficacy; T1: Test 1; T2: Test 2; T3: Test 3; HW: Homework Average; FG: Final Grade

*$p \leq 0.05$; **$p \leq 0.01$

Table 3: Group Means and Standard Deviations for Grades

Variable	Online Homework $\bar{x}$	SD	Traditional Homework $\bar{x}$	SD
Homework grade	22.41	2.26	23.64	1.46
Exam 1	21.90	2.71	22.55	2.08
Exam 2	21.60	2.55	21.90	2.67
Exam 3	19.90	4.44	20.36	3.19
Final Course grade	88.80	9.40	91.44	7.24

At pre-test, students in the traditional homework group showed only slightly higher means on the SELS, as well as slightly higher means on the STARS factors of interpretation anxiety and test and class anxiety, and slightly lower means on the STARS factors of computational self-concept and fear of asking for help. Hinkle, Wiersma, & Jurs (2003) recommend that when treatments are randomly assigned to groups, but participants cannot be randomly assigned to the treatment groups, covariates may be used to statistically control for lack of randomization. Therefore, pretest scores on SELS and STARS factors will be utilized as covariates. Means and standard deviations for the SELS and for the STARS factors at pre-test are shown in Table 4.

Table 4: SELS and STARS factors pre-test Means and Standard Deviations

Variable	Online Homework $\bar{x}$	SD	Traditional Homework $\bar{x}$	SD
SELS	41.39	15.52	44.42	15.53
Worth of statistics	35.30	11.05	35.17	12.61
Interpretation anxiety	29.28	9.62	31.37	8.01
Test and class anxiety	25.33	9.93	27.31	7.65
Computational self-concept	17.25	6.42	16.68	5.07
Fear of asking for help	9.75	5.05	8.60	4.17
Fear of statistics instructor	10.89	3.33	10.80	3.72

The first purpose of this study was to determine whether feedback timing would influence students' levels of statistics anxiety. To assess this outcome, one-way multiple analysis of covariance (MANCOVA) was conducted. MANCOVA was employed because the study utilized one categorical independent variable with two levels, treatment group = group 1 ($n = 36$) and control group = group 2 ($n = 35$), and six continuous dependent variables, the STARS factors. The six factors of the STARS pretest were utilized as covariates in order to correct for initial differences between groups because random assignment was not possible. Group means were adjusted for the influence of the covariates, and appear in Table 5 along with the unadjusted means. Results of the MANCOVA indicate no significant differences between groups on any of the six statistics anxiety factors, $\lambda = 0.90$, $F(6, 58) = 1.04$, $p = 0.41$, partial $\eta^2 = 0.097$. Therefore, there was not enough evidence to reject the first null hypothesis and it was concluded that feedback timing did not influence students' statistics anxiety.

Table 5: Adjusted and Unadjusted Group Means for STARS Factors

Factor	Online Homework Adjusted $\bar{x}$	Unadjusted $\bar{x}$	Traditional Homework Adjusted $\bar{x}$	Unadjusted $\bar{x}$
Worth of statistics	35.30	35.47	33.41	33.23
Interpretation anxiety	25.19	24.86	23.03	23.37
Test and class anxiety	21.69	21.50	20.64	20.83
Computational self-concept	14.57	14.86	13.58	13.29
Fear of asking for help	7.28	7.56	7.92	7.63
Fear of statistics teacher	9.48	9.61	9.99	9.73

The second purpose of this study was to assess whether feedback timing influences students' statistics self-efficacy. Using one categorical independent variable with two levels, treatment group = group 1 (n = 36) and control group = group 2 (n = 35), and one continuous dependent variable, current statistics self-efficacy, a one-way analysis of covariance (ANCOVA) was conducted. Self-efficacy for learning statistics was employed as the covariate as a method to help control for initial group differences in self-efficacy because random assignment to groups was not possible. The covariate of self-efficacy for learning significantly influenced the dependent variable, current statistics self-efficacy, $F(1, 68) = 6.96$, $p = 0.01$, partial $\eta^2 = 0.09$. Group means were adjusted for the influence of the covariate, and appear in Table 6 along with the unadjusted means. Feedback timing did not significantly effect current statistics self-efficacy, $F(1, 68) = 0.13$, $p = 0.72$, partial $\eta^2 = 0.002$. Therefore, there was not enough evidence to reject the second null hypothesis and it was concluded that feedback timing did not influence students' statistics self-efficacy.

Table 6: Adjusted and Unadjusted Group Means for CSSE

	Adjusted $\bar{x}$	Unadjusted $\bar{x}$
Online Homework	58.92	58.50
Traditional Homework	60.11	60.54

The third purpose of the study was to explore whether homework method influences students' grades. A one-way multiple analysis of variance (MANOVA) was used to compare the independent variable, immediate feedback vs. delayed feedback, on five dependent variables: final homework grades, three exam grades, and final grade for the course. Results of the MANOVA showed a significant difference between the groups on the combination of dependent variables, $\lambda = 0.86$, $F\ (4, 66) = 3.04$, $p = 0.02$, partial $\eta^2 = 0.14$. Follow-up analysis of variance (ANOVA) tests indicate a significant difference between groups on final homework grade, $F\ (1, 69) = 8.33$, $p = 0.005$, partial $\eta^2 = 0.096$, but no significant differences on any of the exams or students' final course grade were found. Therefore, enough evidence was found to partially reject the third null hypothesis and conclude that feedback timing has some effect on students' grades. Results of the ANOVAs are presented in table 7.

Table 7: Follow-up ANOVA for each Dependent Variable

Variable	F(1,69)	Sig.	Partial η^2
Homework Grade	8.33	0.005*	0.096
Exam 1	1.44	0.234	0.018
Exam 2	0.26	0.612	0.003
Exam 3	0.29	0.589	0.004
Final Course Grade	1.98	0.163	0.025

5. DISCUSSION AND CONCLUSIONS

The purpose of this study was to determine whether feedback timing for homework would have an influence on graduate students' statistics anxiety, self-efficacy for statistics, and grades in an introductory educational statistics course. Findings indicate that whether students received immediate feedback (via online homework) or delayed feedback (via traditional paper-pencil homework), their levels of self-efficacy and statistics anxiety were not significantly different between groups at course end. Additionally, even though test grades and final course grades were slightly lower for the online-homework group, the differences were not significant. This finding was similar to that of Kassis, Boldt, & Lopez (2008), whose results also indicated no differences in student test grades, and a slight decrease (though not significant) in students' test scores when they used the online homework program.

One interesting finding was that the traditional homework group in the current study scored significantly higher on their homework grade than did the online homework group. A possible reason for this outcome is that since online homework assignments are scored by computer, there normally is no credit given in cases of rounding error. For example, if a student figures the slope of a regression line to be 0.6845, and then uses this slope in rounded form to figure the y-intercept, his/her final equation would be $\hat{y} = 1.67 + 0.68(x)$ as opposed to 1.645 + 0.6845(x). A human instructor grading this problem would notice that the two answers are conceptually the same and the student is correct either way, but the computer grading system would not consider this rounding. Another possible factor may be the strict deadline for assignment completion. Though data were not gathered in this study concerning rate of assignment completion, it is possible that some students in the online homework condition failed to meet the deadline for an assignment, resulting in a zero for the missed assignment. In spite of the lowered homework score for the online homework group, their learning of statistical concepts and procedures was apparently unharmed, as evidenced by the lack of significant differences between the groups' test scores and final grades.

The lack of differences between the two groups is surprising in terms of feedback timing, but perhaps the intervening variable in this sample is feedback type. In other words, though the traditional homework group received delayed feedback, the feedback provided by the instructor was similar to that provided by the online Aplia program (i.e. the drop-down explanation box) in that instructor comments and guidance was present. Incorrect answers were marked as such, but in each instance the correct procedure was demonstrated for students so that they would be encouraged to compare their own version to the correct one. According to Hattie & Timperley (2007), feedback is effectual when it is given in a learning context. This means that if students' homework is simply graded, with incorrect answers marked, and no explanation is given to enhance students' understanding, then feedback merely becomes criticism and does nothing for the students' learning. But when feedback is accompanied by explanation concerning how the student can improve, learning is promoted. This type of feedback may be delayed or immediate, and will have a similar effect as long as students who receive this feedback read and consider the grader's comments when they receive their graded work. Perhaps future researchers should incorporate varying types of feedback along with timing, as it appears that quality of feedback may make up for timing.

An important limitation to this study was the lack of random assignment of students to the two homework groups. Since it normally is not possible to randomly assign students to different sections or semesters of a course, statistical equalization of groups through the use of covariates was implemented as a means to help make up for the lack of random assignment. Even so, the two groups may have differed in ways not measured in this study. A second limitation may be found in the equality of the homework assignments given to each group. Although all assigned homework problems for both methods were meticulously compared in terms of content and difficulty, it is certainly possible that some differences remained. A third limitation may exist in that student learning was only measured in terms of course grades. Grades are not necessarily the best indicator of students' learning or understanding of statistics (Garfield, 1994), and it is certainly possible for students to correctly compute statistical formulas without understanding what they have done (Jolliffe, 1991). Therefore, future researchers should consider measuring students' learning in additional ways such as essays, research projects, or portfolios (Garfield & Chance, 2000).

In this group of educational statistics students, feedback timing made little difference in student outcomes. On the other hand, even though homework grades were significantly lower for the online-homework group, their exam and final course grades were similar to those in the traditional homework group which indicates online homework was equally effective for students in terms of test scores, final grades, and self-efficacy for statistics. Therefore, online homework programs may be considered a useful aid for busy instructors.

Since this was the first attempt at measuring the impact of feedback timing via homework delivery method on students' statistics anxiety and self-efficacy, further research should be conducted with these variables and with other samples, such as with undergraduate students. Also, as other researchers (Hattie & Timperley, 2007; Mason & Bruning, 2001) point out, the immediate feedback, represented in Aplia as the "grade it now" feature, may very well enhance student outcome in other ways not measured in this study. Combined with the "explanation" box, which represents feedback about the process of solving the problem, students potentially gain better strategies for finding their own errors and correcting them which may lead to improved self-feedback skills and better self-regulation (Hattie & Timperley, 2007). Self-regulation involves self-appraisal and self-management, meaning that students with self-regulation skills tend to assess their own abilities more accurately and then adjust their efforts to learn more effectively (Paris & Winograd, 1990). Future research should incorporate self-regulation variables to answer questions of whether online homework makes a difference in student outcomes.

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