AC 2012-4700: MEASURING THE EFFECT OF ONLINE HOMEWORK PROCEDURES ON STUDENT EXAM PERFORMANCE

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Measuring the Effect of On-Line Homework Procedures on Student Exam Performance

Abstract

One of the consistent challenges in education is finding the right mix of assessment tools to both encourage learning and provide an accurate evaluation of students. This challenge becomes even more acute in quantitative courses where students often are tasked to complete a significant number of problem sets to develop their skills. The use of course management software has provided a new method to address some of these challenges. On-line assessments can provide learning and assessment tools that are less labor intensive for the instructors and provide quicker feedback for the students. Using on-line assessments as direct replacements for traditional pencil and paper homework assignments may not, however, take full advantage of the technology.

The purpose of this research effort is to explore whether on-line homework procedures and other background data about the students had a measurable effect on student exam performance. To improve the sampling for the study, multiple sections of an undergraduate Engineering Economy course were studied over multiple semesters. This paper discusses preliminary results obtained from analysis through Exam #1 for 140 students across three sections of Engineering Economy from a single semester. The variables studied include the number of attempts at an assignment, time between attempts, time between first attempt and the deadline, performance on individual homework attempts, first attempt score, maximum score achieved, and average score achieved. Student demographic data, such as total credit loads, number of semesters at the university, transfer student status, current college major, and prior GPA were also reviewed. Other confounding factors were also reviewed, such as attendance at problem solving and recitation sessions. These variables are then compared with student performance on individual exams. The goal of this research is to determine which, if any on-line homework variables have a positive impact on student exam performance.

It is hoped that the results of this research, along with parallel efforts to evaluate the impact of other technologies, such as clickers and financial calculators, can be combined to provide a more effective educational experience to prepare students to become practicing engineers. The preliminary results using logistic regression found that the probability of a student earning an Exam #1 score of 80% or higher was negatively affected by transfer student status and positively affected by recitation attendance and the first attempt score for the fourth homework assignment.

Introduction

As engineering education continues to evolve and instructors strive to integrate technology in the classroom, research must be done to understand the effectiveness or ineffectiveness of the technology. In many higher education institutions around the country, budgets are being cut, the number of instructors is dwindling, and class size is increasing. As a result, instructors turn to technology to improve the educational environment and reduce required resources. The instructors of Engineering Economy at the University of Alabama in Huntsville (UA Huntsville) sought a better way to administer homework and provide students with feedback. An automated online homework grading system was implemented to both improve turnaround time for homework feedback and reduce the teaching assistant resources required in hand-grading homework. However, after three semesters of using this homework system, the instructors wondered how it was impacting student exam performance.

Literature Review

Homework has long been thought to aid students in preparing for exams. Instructors assign and grade homework to help students learn the material for better overall exam performance. This is the conventional belief in most of the academic community. It is only logical to think that practice improves performance in academic studies as it does in many other endeavors.

In 2002, Peters et al.[1] studied the correlation between homework and exam performance in an Operations Management course. The study was designed with two treatments: one treatment was assigned homework and it was collected while the other treatment was assigned the same homework but it was not collected. This study included 330 students in 13 sections over 3 semesters. Peters controlled for class size and instructor. The results showed the treatment not required to turn in homework actually scored higher on the exam. As a result, the study found that homework did not have an effect on exam performance.

In 2006, Fernandez et al.[2] studied 4 different engineering courses to better understand the relationship between homework, quizzes, tests and final exam performance. Fernadez studied Statics, Fluid Mechanics, Water Resource Engineering, and Engineering Administration which includes Engineering Economy material. The study included 24 total sections over a 5 year period. The analysis included calculating the Pearson coefficient for all homework, quizzes, tests, and final exam scores. The strongest correlation was found between quizzes, tests, and final exam scores. The final regression model showed only quizzes, tests and final exam scores to be significant. The study's findings indicated that homework might not lead to exam success.

Researchers also looked at how online homework scores related to exam performance or course grade. In 2007, Lass et al.[3] studied the effects of online assessment in an Introduction to Statistics course. The study included 3 semesters with one of the semesters used as a control. The study modeled each exam throughout the course and included not only online assessment scores but also demographic and past performance data such as gender, university GPA, and high school GPA. Lass also included a binary variable to indicate whether the student took the course in sequence or waited until later in the curriculum. The study modeled Exams 1, 2, and 3 individually. However, previous exam scores were used as predictor variables in later exam models. For example, for the Exam 2 model, Exam 1 score was added as a predictor variable. The results showed that the online assessments did improve student exam performance compared to the control semester. Also, college GPA and high school GPA were found to be very important in predicting performance. The researchers also investigated the link between homework procedures and student performance. They studied whether variables that represented student interaction with the online homework system might correlate with student performance.

In 2005, Taraban et al.[4] studied students' interaction with an online homework system in two sections of Thermodynamics in a single semester. The two sections were held at two different universities: University of Wyoming and Texas Tech University with two different instructors but the same online homework tool. The study showed that there was little to no significant relationship between homework scores and exam scores. However, at both institutions there was a relationship between the total time completing homework and exam scores.

In 2007, Bennett et al.[5] studied student behavior with an online homework system for college courses in Trigonometry, Calculus 2, and Elementary Differential Equations. The system offered multiple attempts but each time the values in the problem would change. The researchers found that the inverse of the number of attempts on a particular homework concept was an important variable in determining concept mastery.

Finally, in terms of student interaction with a course management system, Biktimirov and Klassen[6] in 2008 studied students' access to online course materials such as presentation slides, homework solutions, and exam solutions. The course management system captured the number of "hits" during the course of the semester for each student. Then they correlated the students' interaction with the course management system to their overall course grade. The results showed that the only significant variable was the number of homework solutions accessed over the semester.

Background

This research was conducted on multiple sections of Engineering Economy taught by different professors (full time and adjunct) at UA Huntsville. The results presented here are from three sections in the Fall semester of 2010 with a total of 140 students. At this university, Engineering Economy is a junior-level course required for most engineering majors. It is optional for chemical and material engineering majors. However, this class is known to be popular for first semester transfer students as well. Many students choose to take their first two years at less expensive community colleges and then transfer for their more advanced coursework. Advisors in the college suggest that transfer students take this course because its only prerequisite is sophomore standing. As a result, the class composition is unique in that although the students are in a junior-level course, they may not be as familiar with the university and its standards. Another factor at this university is that many students are "nontraditional" in that they are working part or full time, have families, or are returning to school after pursuing other activities since high school graduation.

Class Organization

Although the three sections were taught by three different instructors, each section relied on common course component weighting, homework assignments, examination schedules, and content coverage. The course components included exams, class exercises, and homework. The course included three exams weighted evenly for a total of 60% of the course grade. The class exercises were both in-class and out-of-class assignments that each focused on one learning objective to assess student understanding. The in-class assignments were unannounced to encourage class attendance. The out-of-class assignments were Excel models to encourage Excel financial function mastery and spreadsheet usage. The class exercise grades accounted for 20% of the course grade after dropping the lowest exercise percentage score. The scores for class exercises and homework assignments were calculated on a percentage basis from the points earned out of the total points available. The homework assignments were given, on average, once per week. The course included 10 homework assignments, which were completed online using a multiple-choice format. The average of the 10 homework assignment scores accounted for 10% of the course grade after dropping the lowest assignment percentage score.

The three sections differed in a few ways. The sections met on different days and times so the actual examination problems for the three sections were not identical but the content covered was similar. The class exercises differed in design, number, and timing throughout the semester. However, the homework assignments were identical across sections. A single teaching assistant offered assistance four days a week during scheduled office hours to all three sections. A voluntary recitation session was held twice a week for 50 minutes. During the recitation sessions the teaching assistant worked problems similar to the homework questions, discussed topics related to Excel, and answered questions about the homework.

Online Homework Procedures

The online homework was created using the functionality of the ANGEL®[7] course management system. The procedure was designed to allow the students to solve the textbook problems assigned and then login to an online assessment for electronic grading. This design allowed students to work the problems at a personally comfortable time, pace, and location. It also allowed them to receive instant feedback on their work.

The online homework system was designed in a multiple choice format. Students worked the problems from the text, and the assessment posed a question about each problem with four possible answers. The three incorrect answers were chosen to mirror the results obtained by making typical errors. Each homework assignment included approximately ten problems and was representative of the material covered in that chapter.

Each online homework assignment allowed three attempts. Each attempt was composed of identical problems but the order of the answers was randomized. Thus the correct answer to a question may have changed from choice a) on the first attempt to choice c) on the second attempt. The assignment score recorded in the course grade book reflected the average of the total number of attempts for that assignment. For example, if a student scored 80, 90, and 100 for the three assignment attempts for Homework #1, the Homework #1 assignment score would be 90. If another student scored 90 and 100 and used only two attempts for Homework #1, then the assignment score would be a 95. Students quickly realized that in this scenario they would earn a higher score if they repeated the assessment a third time to earn a second 100 and increase the average.

Because these homework assignments were identical for each student and the questions had multiple choice answers, the instructors realized that either guessing or the sharing of answers among students was possible. To counteract the effect of this behavior, the homework grade was assigned a relatively modest weight of 10% for the overall course grade calculation. The homework was designed to be a learning tool with the belief that honestly completing the homework would lead to a higher exam grade. Students were encouraged to work together with the advice that everyone should learn how the problems were solved rather than "free-riding" on more skilled study partners.

This method for administering homework grew from the opinions of the instructors that although homework was important for students to complete, the time required for manual grading was non-value added for students. This online method was seen as superior because students received more timely feedback and the instructors could spend more time on course preparation. The time the teaching assistant would otherwise have spent grading was directed instead towards recitation and more office hours. Also, with the rise in student enrollment, class section size could increase with a smaller impact on the resources needed for each section. Once the online homework assessment was created for one section and uploaded to that section's course management site, it could easily be electronically copied to the other sections' course management sites. The automated grading and logging of scores in the course management system's gradebook reduced the effort required to support a larger enrollment. Another advantage of the online homework was that instances of disputed scores and requests for re-grading were reduced to nearly zero. Some additional time was required to create and test the online assessments, but this was much less time-consuming than grading homework manually. There is a difference in when the time is required. The majority of effort involved by the instructor/teaching assistant with manual homework assignments is in grading it after its collection. With online homework assignments most of the effort by the instructor/teaching assistant is in advance of the assignments.

Exam Procedures

Each instructor wrote separate exams for their own section and graded them using their professional judgment. The exams contained a mix of short and long quantitative problems to be solved. Some of the problems also involved interpretation of the results and providing a conclusion. Partial credit was given when students' logic in solving the problem could be followed and certain common errors were made. Some questions involved short verbal answers but multiple choice questions were not used. The exams were "open book" so students were permitted to use their textbooks. They were also encouraged to prepare a hand-written formula sheet not to exceed one 8.5 x 11 inch double-sided paper. Students were also permitted to use engineering or financial calculators. Cellular telephones with calculator features were not permitted to be used due to concerns about the risk of academic dishonesty.

Data Collection

In identifying potentially significant information to develop a predictive model, five distinct sources of data were identified including the course grade book, homework submission information, recitation attendance, student information surveys, and student background information. Three of these sources were located within the course management system, ANGEL. The university's student database, Banner®[8] which held the student background information, is a separate system and only authorized university personnel can access system data. The recitation attendance was kept by the teaching assistant. All of these data were obtained for each student in the three sections for Fall semester 2010. Table 1 displays the types of data and sources for the study.

Table 1 – Data Sources

Data Classification	Source	Types of Information
Course Grade Book	ANGEL	Exam Scores; Final Homework Scores, Class Exercise Scores
Homework Submission Data	ANGEL	Homework Attempt Scores (up to 3 per student per homework assignment); Homework Attempt Time and Day
Student Information Survey	ANGEL	Major; Credit Hour Load at the university; Employment; Number of semesters at UA Huntsville
Recitation Attendance Data	Collected by Teaching Assistant	Student attendance at recitation for each recitation session
Student Background Information	University's Student Database (BANNER)	Transfer Student (y/n); Repeating Engineering Economy (y/n); Transfer GPA; High School GPA; SAT/ACT Scores

<u>Course Grade Book Data</u>

Key variables were gathered from the course grade book located in ANGEL including final homework scores, examination scores, and the number of missing homework assignments or class exercises. Finally, the grade book contained both students that completed the course as well as students that withdrew from the course during the semester.

<u>Homework Submission Data</u>

Homework submission variables were gathered from each homework assessment in ANGEL. The submission variables not only included the score for each homework assignment submission attempt but also indicated the students' behaviors when completing the homework. The homework submission variables describing student performance included the number of attempts for a specific assignment out of the three attempts permitted; the score of the first attempt of the homework assignment; and the range of the attempt scores for each homework assignment. The number of attempts and range of attempts were calculated after manipulating the submission data exported from ANGEL to Microsoft Excel®. The homework submission variables describing the students' interaction with the online homework included the time between the first and last attempt of the homework assignment and the time between the first attempt and the due date of the homework assignment. These variables show when students started the online homework assessment and how long they took to complete their homework attempt(s). These data were calculated by using the submission time stamp data from ANGEL for the time of each submission. A macro was written in Excel to transform submission time stamp data into these meaningful variables. Both the performance and interaction submission variables were collected as potential covariates in predicting exam performance.

<u>Student Information Surveys</u>

The student information surveys were administered to the students at the beginning of the semester via an automated online form in ANGEL. The purpose of the survey was to enable the instructors to better know the students and learn about their commitments outside of the Engineering Economy class, previous experience at the university, preferred contact information, and current Excel skills. Researchers hypothesized that some of this information might also be predictive in the proposed model. The following information was gathered from the online student information sheets: major, credit hour load, outside employment level, and number of semesters at the university. The number of semesters at the university was of particular interest because many transfer students take this course during their first semester. Credit hour load responses were categorized as part-time, full-time, or overload. Employment had three response categories including no employment, part-time, or full-time. The number of semesters at the university had four categories including first semester, second semester, third semester, or four or more semesters. This student information created demographic variables that might contribute to predicting the success of students in Engineering Economy.

Recitation Attendance Data

Recitation attendance was kept for each twice-a-week session throughout the semester. The students manually signed an attendance sheet with their names and that of the professor for their section. The data were then compiled into a spreadsheet showing how many times and when in the semester each student attended recitation.

Student Background Information

The university's student database (BANNER) offered additional demographic data that was thought to have predictive utility in the model. An authorized user of BANNER gathered historical information about students' past performance including high school GPA, UA Huntsville GPA as of August 2010, ACT/SAT score, and whether the student transferred into the university from another institution. Not all of these measures were available for each student. For example, if this was a student's first semester at the university, he/she would not have a UA Huntsville GPA. Also, if the student was a transfer student from another institution, the high school GPA was not required for admission, only the transfer GPA. A separate transfer/non-transfer student variable was created to distinguish between the students. BANNER also provided information about whether students had previously enrolled in Engineering Economy. It was theorized that if students repeated the course, their performance on class assignments in the second enrollment could be affected by prior exposure to the material. These BANNER variables completed the demographic picture of the students, used in predicting Engineering Economy examination scores.

Data Conversion

Once the data were collected, the next step was to convert the data into meaningful variables for analysis. Data collected were binary, nominal categorical, ordinal categorical, and continuous. Some of the data conversion occurred prior to parametric analysis although most conversions occurred after computing summary statistics and identifying trends. These analyses are discussed in the Results section. The conversion process required a significant amount of time since a large volume of data was collected and almost all of it was categorical.

Course Grade Book

The course grade book variables, homework scores, examination scores, and class exercise scores were maintained as continuous variables. The examinations and the examination grading with partial credit were not uniform across the sections. To account for the difference in the three sections, a nominal section variable was also created. Two separate “dummy” indicator variables were used to represent this variable in the prediction modeling.

The class exercise scores were combined to create class exercise variables that represented the average of the class exercises taken prior to a specific exam. The class exercises were unique to each section; therefore, each section had a different number of class exercises. Class exercises were a mix of in-class quizzes and out-of-class Excel models. It was determined that for predicting exam performance, only in-class exercises would be included in the class exercise variable. The in-class exercises were then mapped to the three exams in the class. The variable “Class Exercise Average Prior to Exam 1” was created by averaging the class exercise scores that occurred prior to Exam 1.

The course grades were coded differently if students missed an assignment or if the students dropped the course during the semester. The course grade book only showed an assignment as missing. Instead of coding all missing grades as zeros, it was important to distinguish between missing assignments, which resulted in a grade of zero, and an assignment that occurred after a student dropped the course. This was difficult because, although the student was identified as dropping, the actual date was not recorded. In the data coding process for dropped students, missing grades were considered dropped if they were previous to a missed exam. If an assignment was missing, the grade was zero but if an assignment was missing because of a student dropping the course that grade was considered missing data. As long as a student remained in the class through Exam 1, all the assignment scores to that point were used.

Homework Submission Data

Homework submission data included five variables computed from homework submission time and date information. These variables included the number of attempts for each homework assignment; the first attempt score of each homework assignment; the score range of the attempts for each homework assignment; the time between the first and last attempt of each homework assignment; and the time between the first attempt and due date for each homework assignment.

Number of Attempts

The number of attempts variable was gathered for each of the 10 homework assignments. This variable ranged in value from 0 to 3. A zero signified that the student did not attempt the assignment while a 1, 2, or 3 signified the number of times a completed homework assignment was attempted. This variable was kept as an ordinal variable.

First Attempt Score

The first attempt score was captured for each homework assignment as a percentage of the total point value. This variable was kept as a continuous variable from 0 to 100. If the assignment was not attempted, the first attempt score was zero.

Range of Attempts

The range of the attempts for each homework assignment was calculated by subtracting the minimum score from the maximum score. Instead of keeping this variable as a continuous variable from 0 to 100, a new categorical nominal variable was constructed with four categories: one attempt for a homework assignment (meaning no range could be calculated), the range is greater than a certain value, the range is less than a certain value, or no attempts for this homework assignment. The value 50 was chosen as the breakpoint because it was near the median value of the range of scores. The values assigned represent the belief that students who earned higher grades in the course either attempted homework only once or their score ranges were smaller; no attempts or a greater score range were more indicative of students who earned lower grades in the course. Then a binary variable was created for each student by homework assignment. The variable was coded as a 1 if a student made only one attempt or the range was less than 50. It was coded as a 0 if a student made no attempt or the range was greater than 50.

Time between First and Last Attempt

The time elapsed between the first and last submission of each homework assignment indicates how students interacted with the homework. For example, after the first attempt of the homework, students could rework the problems that were incorrect or they could attempt to guess the correct answers from the remaining choices. This measure is continuous and ranges from minutes to days. A longer time gap suggests a student may have been reworking incorrect problems as opposed to just guessing at alternative answers. To create a more concise measure, a nominal categorical variable was constructed including four distinct categories: one attempt for a homework assignment, greater than 10 minutes, less than 10 minutes, and no attempts for this assignment. The value of 10 minutes was used because this was the approximate median time observed for this variable. Again, a binary variable was created for each student by homework assignment. The variable was coded as a 1 if a student made only one attempt or the time between attempts was at least 10 minutes. It was coded as a 0 if a student made no attempt or the time between attempts was less than 10 minutes.

Time between First Attempt and Due Date

The time between the first attempt on each homework assignment and the due date of that homework assignment was also captured. This measure could also range from minutes to days. Again, this continuous variable was transformed into a nominal categorical variable. The variable's possible values were divided into three categories: less than 8 hours, more than 8 hours, or no attempts for each assignment. The 8-hour value was used because it was an approximate median of the continuous measure. This finding confirmed the instructors' initial impression that students often procrastinate starting assignments, but the degree of procrastination was startling. Another binary variable was created for each student by homework assignment. The variable was coded as a 1 if a student first attempted the homework at least 8 hours before it was due. It was coded as a 0 if a student first attempted the homework less than 8 hours before it was due. This coding represents the belief that students who completed their first attempt earlier may be more organized and able to ask questions on challenging questions before the due date which would result in more learning and a higher score on the assignment and subsequent exam.

Student Information Surveys

The student information surveys were a source of demographic data including major, number of credit hours in the current semester, employment, and number of semesters at the university. These attributes were thought to potentially influence exam performance. Eleven students chose not to complete the student information survey. These missing attributes were coded as missing values.

Major

Students were given a choice among ten different majors in engineering. Initially, the majors were coded 0 through 9. However, once it was determined that few students were classified as chemical, civil, industrial, optical, or other, these choices were combined into a single category. Also, during Fall semester 2010, no computer engineering or business majors were enrolled in Engineering Economy. As a result, the variable major was coded with 5 categories for Aerospace, Mechanical, Electrical, Chemical/Civil/Industrial/Optical, or missing if no response was given. Major was a nominal categorical variable so indicator variables were used to model this variable.

Credit Hour Classification

The student information survey asked how many credits the student was taking at the university in the current semester. The responses were classified as part time, full time, or “overload” enrollment. Part time was defined as less than 12 hours; full time was considered between 12 and 18 hours; and an enrollment of over 18 credit hours was designated as overload. Because only one student was classified in the overload category, full time and overload students were merged in the same category; part time was a separate category; and a third category reflected missing data. In data collection for later semesters this was expanded to capture additional credit hours if students were simultaneously enrolled and taking classes at a different school such a local community college. This was not captured in the Fall 2010 data so it is likely that some students appeared to have less demanding enrollment schedules than they really did.

Employment

The student information survey asked students if they were employed and, if so, to specify the employment as part time or full time. Because very few students worked full time, the variable was divided into two categories: employed or not employed. A binary variable was used for this data in the modeling.

Semester Count at University

To determine how long students had attended UA Huntsville, the student survey asked how many semesters, including Fall 2010, the student had attended the university. In other words, were students new to UA Huntsville? The responses to this question included: first semester, second semester, third semester, and fourth semester or more. This variable was coded as ordinal categorical with values of 1 through 4.

Recitation Attendance Data

Recitation attendance was taken by the teaching assistant during all recitation sessions except the first session. The recitation log showed not only which students attended recitation but also the actual sessions they attended. The recitation sessions were then mapped to exams in the course.

A variable was created for recitation attendance prior to Exam 1. The variable could range from 0 to 4, with 4 being the maximum number of sessions that students could have attended before Exam 1.

Student Background Information
The student background information was acquired through the BANNER system. The categories included whether the student transferred to UA Huntsville, if the student had taken Engineering Economy before, transfer GPA, High School GPA, ACT/SAT scores, and UA Huntsville GPA as of the beginning of Fall 2010.

Because these data were gathered from admission information, some of the data were incomplete. For example, transfer students are not required to provide their high school GPA or ACT/SAT scores. Because 87 of the 140 students in the study were transfer students, many students in the sample had incomplete data. Also, students who started at the university originally (53 of 140) only had their high school GPA. Finally, the university cumulative GPA was available for most students except for students whose first semester at the university was Fall 2010 (41 of 140).

Because many of these metrics were incomplete, a hybrid variable was created which represented prior GPA. For a transfer student, the variable was the transfer GPA and for a non-transfer student, it was the high school GPA. The high school GPA was translated to a uniform 4.0 scale. This variable, along with the transfer status variable and Engineering Economy repeat enrollment variable, gave past performance metrics.

Analysis Methodology

The analysis methodology began with macro level summary statistics. Then the data were manipulated to present descriptive charts that could identify trends and compare metrics across class sections. The last stage of the analysis included building logistic regression models to determine if online homework procedures were predictive of exam performance.

After the data were analyzed through graphs and summary statistics, statistical models were built to predict exam performance based on the variables outlined in the previous sections. Logistic regression was chosen because of the non-normality of the outcome variable (exam scores) and the many categorical variables. For a logistic regression model, the outcome variable must be dichotomous. As a result, the exam score variable was transformed to a binary variable with 1 indicating the score was 80% or higher (A or B) and 0 indicating the score was less than 80% (C, D, or F). Multinomial regression was considered but rejected because of concerns that there was not a large enough sample size for this technique.

Instead of one model that predicts the overall course grade, three models were built to reflect the probability of earning an A or B on Exam 1, 2, or 3. All three models included all three sections. The goal of the study was to understand the metrics that influenced exam performance regardless of the section or instructor.

SPSS® 19 was used for the analysis. First, univariate analysis was used to determine if the categories were appropriate for the categorical variables constructed. Analysts checked that at least 5 observations were in each category[9]. For the multivariate analysis, forward selection was used to determine which of the potential variables were significant in predicting exam performance. In forward selection, a *p*-value of 0.05 was used to select variables to enter the model while a *p*-value of 0.10 was used to determine which variables would leave the model.

In the three models, different variables were used to predict performance. Table 2 shows the variables that were used as potential covariates to model the probability of earning an A or a B on Exam 1.

Table 2 - Potential Variables for Exam 1 Model

Variables	Role	Selected
Exam #1 Score	Outcome	X
Gender	Covariate	
Major	Covariate	
Credit Hour Classification	Covariate	
Employment	Covariate	
Semester Count	Covariate	
Prior GPA	Covariate	
Transfer	Covariate	X
Repeating the Course	Covariate	
Recitation Attendance prior to Exam 1	Covariate	X
Class Section	Covariate	X
HW #1 Final Score	Covariate	
HW #2 Final Score	Covariate	
HW #3 Final Score	Covariate	
HW #4 Final Score	Covariate	
Class Exercise Average Prior To Exam 1	Covariate	X
HW #1 Number of Attempts	Covariate	
HW #1 First Attempt Score	Covariate	
HW #1 Range of Attempts	Covariate	
HW #1 Time between First Attempt and Last Attempt	Covariate	
HW #1 Time between First Attempt and Due Date	Covariate	
HW #2 Number of Attempts	Covariate	
HW #2 First Attempt Score	Covariate	
HW #2 Range of Attempts	Covariate	
HW #2 Time between First Attempt and Last Attempt	Covariate	
HW #2 Time between First Attempt and Due Date	Covariate	
HW #3 Number of Attempts	Covariate	
HW #3 First Attempt Score	Covariate	
HW #3 Range of Attempts	Covariate	
HW #3 Time between First Attempt and Last Attempt	Covariate	
HW #3 Time between First Attempt and Due Date	Covariate	
HW #4 Number of Attempts	Covariate	
HW #4 First Attempt Score	Covariate	X
HW #4 Range of Attempts	Covariate	
HW #4 Time between First Attempt and Last Attempt	Covariate	
HW #4 Time between First Attempt and Due Date	Covariate	

Results

The Exam 1 model analyzed 120 records. Twenty records were missing because students did not complete the student survey or withdrew before Exam #1. All of the potential variables for the Exam #1 model were included in the analysis, but the forward selection algorithm chose only five covariates for predicting the outcome variable in the final model.

Table 3 shows the results of the forward selection algorithm. The resulting model included section, transfer status, recitation attendance, class exercise performance, and the first attempt score for Homework #4 as significant predictors of Exam #1 Score. The model indicates that students scored higher if they were in Section 03. Non-transfer students had a greater chance of scoring 80% or higher on Exam #1. Students who scored higher on class exercises and the first attempt of Homework #4 tended to do better than students who did not. Because Homework #4 was influential in predicting Exam #1, it is not surprising that it was the last homework assigned before Exam #1. Homework #4 contained some of the most complex core material for the subject of Engineering Economy. In addition, the material was cumulative so if students did well on Homework #4 they typically understood previous material. Students who attended Recitation prior to Exam #1 had a better chance of scoring a B or higher on Exam #1. In fact, the coefficient indicates that for every additional recitation attended the odds of scoring a B or higher increased from 1.0 to 2.312.

Table 3 - Variables in Model Equation for Exam #1

Variables	β coeff.	Standard Error	Wald	df	Signif.	Exp(β)
Section			17.937	2	0.000	
Section 1	-3.112	0.735	17.934	1	0.000	0.045
Section 2	-1.819	0.666	7.454	1	0.006	0.162
Transfer Student	-1.775	0.542	10.719	1	0.001	0.170
Recitation Attend. Prior to Exam 1	0.838	0.408	4.219	1	0.040	2.312
Class Exercise Avg. Prior to Exam 1	0.035	0.012	9.000	1	0.003	1.036
HW #4 First Attempt Score	0.024	0.009	6.874	1	0.009	1.025
Constant	-1.665	0.931	3.199	1	0.074	0.189

A Hosmer and Lemeshow Test[10] for goodness of fit produced a chi-square result of 2.163 with 8 degrees of freedom and a *p*-value of 0.976. This indicates that the model adequately fits the data.

Table 4 shows the variable and classification statistics for each step in the forward selection process. The model with no predictors had a classification percentage of 53.3% but the final model with all 5 covariates had a classification percentage of 80%.

Table 4 - Summary Table – Exam #1 Forward Selection and Classification

Step	Model Chi-square	df	Sig.	Correct Class %	Variable
1	13.110	1	.000	64.2%	HW #4 First Attempt Score
2	23.412	2	.000	66.7%	Transfer Student
3	37.741	4	.000	73.3%	Section
4	52.033	5	.000	79.2%	Class Ex. Avg. Prior to Exam 1
5	57.139	6	.000	80.0%	Recitation Attend. Prior to Exam 1

Conclusions

The model demonstrated that as expected, homework does have a positive influence on exam performance, but the relationship in this analysis is not nearly as dramatic as educators would wish. Homework overall was not the sole factor or set of factors. Instead, a single critical homework assignment was a good predictor of Exam #1 performance. The Exam #1 model showed that participation in recitation, homework, and class exercises during the first third of the course was predictive of better student performance. Students who scored well on in-class exercises, scored well on the first attempt of the last homework before the exam, and attended recitation sessions improved their probability of earning a higher score on Exam #1. The only significant demographic variable was transfer student status which had a negative association with exam performance. Because many first semester transfer students routinely enroll in this course, instructors may need to implement changes to better orient new transfer students to course and university standards.

Not surprisingly, class section was a significant variable in this model. The class section variable took into account the teaching, testing, and grading methods of each instructor. Students tended to do better if they were in Section 03. This section was taught by an adjunct instructor, and the other two sections were taught by full-time professors. This difference could stem from a number of factors including the difficulty of the exams, the partial grading method use for each exam, or the quality of instruction. One question that was not explored in this analysis was whether the predictive ability of online homework was significantly different from that offered by traditional manual homework.

Future Work

The data, results, and conclusions examined to date are only the beginning of possible research in this area. Not only could more research be undertaken with additional semesters of data but also with the data that has already been collected.

The Fall 2010 data could be analyzed to answer additional research questions. In the current study, the effects of potential variable interactions are not well understood. The cut point that SPSS uses to determine predicted categories was not changed, thus changing the cut point could lead to a better understanding of the model. The exam variable was coded dichotomously with a

B or higher being the breakpoint. It would be interesting to explore what might happen if the variable had a more stringent breakpoint of A or higher or a less stringent breakpoint of C or higher. For the homework procedure variables, the continuous variables such as Time between First Attempt and Due Date, were changed to binary categorical variables. The median was used as the breakpoint. Different techniques for changing these continuous variables into categorical variables could result in different results. Another potential avenue of inquiry is exploring the actual homework procedures by altering them to determine if homework procedures could be shown to predict homework scores. Because it is understood that homework scores affect exam performance, research could continue in an attempt to discover optimum strategies for students to interact with online homework and best practices for administering online homework.

Subsequent semesters involved different exam policies such as open notes, close book/closed notes, an official formula sheet, multiple choice exams, etc. Students began collaborating on homework in much larger groups. Some exams were standardized across semesters while in other semesters the exams were quite different. In semesters where course sections utilized common exams, instructors, and grading methods it was hypothesized this might decrease the variability of exam scores and hopefully decrease the influence of section assignment. When section variability decreases, the model results may be more replicable. These different policies resulted in additional data collected to validate the findings of this study and extend them.

As more data becomes available, multinomial logistic regression could be used to predict exam performance. Instead of exam scores being dichotomous variables, these scores could be divided into several categories for each grade level. More detailed information could be gathered on the student survey about employment, prior classes taken, and from which schools students have transferred. Additional data could be gathered from ANGEL through use of an access tracking log that identifies which students accessed homework assignments and solutions. The tracking features can determine when (if at all) students accessed the course materials. These data may provide a more accurate timeframe for when students began working on the homework problems. Currently, the first attempt only records when students make their first submission, not when they actually started working on solving the problems. Parallel efforts are being explored to evaluate the effect of using student response units (a.k.a. "clickers") and financial calculators on the learning process. Clicker units would provide additional assessment data on a real time basis after introducing new topics. Additional research on this subject will give instructors and students more information about how to improve teaching and performance in the classroom. Instructors can improve the class by adjusting homework procedures, and students can improve performance through understanding and acting on the potential keys to their success.

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