A PRELIMINARY STUDY OF GRADUATE STUDENT PERFORMANCE AND ONLINE HOMEWORK PROGRAMS IN OPERATIONS MANAGEMENT

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ABSTRACT

This study analyzes student performance between different treatments of homework problems: online homework management systems (Required or Suggested homework) and Traditional (paper and pencil) homework in a graduate introduction to operations management course. Preliminary results reveal significant differences in student performance for open-ended questions but not scaffolded questions. Implications for instructors and computer managed systems may exist.

Key Words: online homework programs, traditional homework, student performance

LITERATURE REVIEW

As education continues to add evolving technology into the delivery methods, instructors need to evaluate the relevance of the various activities used to assess student performance, particularly as more courses and programs transition to the online environment. The techniques, which may include homework, quizzes, exams, discussion boards, case studies or other activities, should motivate and enhance student learning. Traditional education in terms of face-to-face (FTF) instructional delivery using paper-and-pencil assessments continues to be modified and include more ‘virtual’ elements. ‘Virtual’ elements exist in online programs, hybrid (or low residency) programs, online courses (100% online), hybrid courses (substantial portion online and substantial portion FTF), and blended courses (campus-based courses that use online components). A recent study by the Babson Survey Research Group noted that over 6.1 million students took at least one online course during the fall 2010 term, an increase of 560,000 students over the previous year (Allen and Seaman, 2011). Much research remains to be evaluated in the online arena and the value of course-support materials (Biktimirov and Klassen, 2008). With respect to hybrid courses, which are the more common method with online materials used to supplement traditional FTF teaching, a lack of research on best practices exists (Baugher, Varnelli and Weisbord, 2003).
In the FTF environment, instructors view homework as improving students’ abilities, knowledge and material retention; however, this is not always the case. Educators assign homework because they believe that by doing homework, students engage in the activity and that it can assist students to study (Rayburn and Rayburn, 1999). However, actual results regarding student performance and its relationship to homework are mixed. Business studies that demonstrate a positive relationship between homework and performance include an accounting course (Rayburn and Rayburn, 1999) and a first year financial accounting course (Eskey and Faley, 1988). However, other studies did not find a positive impact, including an introductory operations management class (Peters, Kethley & Bullington, 2002) which concluded that required homework is not significantly related to performance on a multiple choice exam. Thus, the debate regarding the value of homework to student performance continues to be mixed.

While empirical research supports the view that online ancillary materials can enhance student performance, results for online homework are mixed (Smolira, 2008). Several studies demonstrate positive relationships between online homework and performance. For example, in an introductory finance course, a positive relationship between student performance and access to online homework solutions exists (Biktimirov and Klassen, 2008). Similarly, in a chemistry class, student performance was significantly better with online homework versus a control group (Arasasingham et al., 2005; Arasasingham et al., 2011).

Yet, other studies demonstrated negative or indifferent results with respect to the relationship between performance and online. For example, another study found no significant differences between classes that used online homework and those that used text-based homework in the traditional written format in the sciences (Cole and Todd, 2003) or in physics (Bonham, Beichner and Deardorff, 2001; Bonham, Deardorff, and Beichner, 2003). In another empirical study of management students in online and traditional FTF courses, results suggest that undergraduate students perform equally well in both environments (Daymont & Blau, 2008). Student performance appears to be indifferent between the two environments (Horspool & Lange, 2012; Topper, 2007). Others noted weak correlations between online homework and student performance on examinations (Fisher and Holme, 2000; Chamala et al., 2006). In yet another study, student performance in online statistics and economics courses produced inferior learning outcomes relative to the traditional environment (Anstine and Skidmore, 2005). Researchers did not detect any significant differences in predicting student success for several Web-based homework systems for teaching undergraduate business statistics (Palocsay and Stevens, 2008). Students using online computer-generated math homework did not perform better on examinations; however, students’ success rate in the overall course grade appears to be better than the traditional homework group (Kodippili and Senaratne, 2008). In a comparative study between four instructors using the same online homework system, only one instructor noted student improvements in exam performance through online homework while three others did not detect any significant gain (Dufresne et al., 2002). In short, there is still a lack of consensus regarding the effectiveness of online homework which highlights the need for further investigation (Arasasingham et al., 2011), and one should view these results with caution due to the differences between instructor effects, instructional methods, prior student knowledge, technical ability, learning styles, and media differences (Horspool & Lange, 2012).
Online homework offers several benefits to students and instructors over the traditional paper-and-pencil methods including:

- Students receive immediate feedback which can increase student performance (Kulik & Kulik, 1986).
- Algorithmic (versus static) problems can reduce the possibility of student’s copying from one another (Smolira, 2008).
- Students can repeat units multiple times with virtually an unlimited pool of questions to work with (Arasasingham et al., 2011).
- Early feedback on student learning is provided that allows instructors to change instructional methodologies or clarify concepts during instruction (Arasasingham et al., 2011).
- The instructor spends less time grading homework.
- Each student receives a new and different set of problems on each topic, changes them each time the student logs in again, makes the students think and encourages them to really understand the material (Arasasingham et al., 2011).

From a student perspective, students appreciate online homework most when it is easy to use, carefully planned and integrated seamlessly with course material, and supported by the instructors (Arasasingham et al., 2011).

From an instructor perspective, positive aspects of online homework including keeping the class on task and on track, and students could work at their own pace on different practice problems (Arasasingham et al., 2011). In some Web-systems, the instructors can track individual student progress and pinpoint exactly where student difficulties lie (Mendicino, Razzaq and Heffernan, 2009). However, other instructors may find online instruction too time-intensive, relationally unrewarding due to the continual e-monitoring throughout the course, and feel a loss of the relational interactions with students (Bejerano, 2008). In general, if course instructors enthusiastically embrace the online approach and integrate assignments with course material, then the students embraced it as well (Arasasingham et al., 2011). Educators cannot use a ‘one-size fits all’ approach with respect to online homework systems as not all students benefit equally from online homework systems (Peng, 2009).

With respect to online homework, researchers are just beginning to explore new technology’s effect in the educational setting and individual differences. Although 62% of academic leaders believe that learning outcomes of online education are the same or superior to those in traditional FTF education (Allen & Seaman, 2013), critics argue that due to intrinsic differences, online education does not replicate the learning that occurs in the traditional classroom (Bejerano, 2008). Correctly or incorrectly, educators assume that whatever information technology is implemented in a classroom, it contributes to student learning (Peng, 2009). Educational settings can include student performance differences with respect to many facets such as the number of times students may retry problems, availability of instruction manuals and ungraded problems, seeking mastery versus limited attempts, static versus algorithmic problems, unlimited versus limited completion time, and printing abilities. For instance, some researchers question the number of times to re-try homework as some feel it may lead to students not studying as hard since they know they can rework their mistakes. That is, using multiple tries for online homework encourages a ‘guess-and-check’ strategy instead of careful reasoning to solve a problem (Pascarella, 2004). Similarly, a study of an operations management online homework
system found that allowing for 4 attempts instead of just 2 actually decreased student success (Yourstone, Kraye & Albaum, 2010). With respect to performance differences between FTF and online education, academic maturity is a significant factor as freshman perform significantly worse than upperclassmen (Urtel, 2009). Similarly, in a comparison of graduate and undergraduate performance on online homework, undergraduates performed significantly worse than graduates (Fish, 2012). However, the relationship between performance and ethnicity (white, black or Hispanic) is not significant for blacks or Hispanics; however, Caucasians tend to do better in FTF. Gender is not a significant factor (Urtel, 2009).

Clearly, while various studies explored the value of homework to the learning environment, a question as to its value at the secondary education level remains. Added to this is the question of the value of online homework instead of traditional homework. Also, only one study tested the type of questions (multiple choice) in relation to homework (Peters, Kethley & Bullington, 2002). Hence, homework questions versus the types of questions used on exams is another area open for research. Therefore, the question of student performance on homework and its relationship to classroom performance persists as an area for study.

The field of education develops and evaluates methods to teach students. Bloom’s taxonomy outlines a framework for classifying what instructors expect students to learn as a result of instruction (Krathwohl, 2002). Students are expected to learn knowledge ranging from concrete to abstract, and may be categorized as factual, conceptual, procedural and metacognitive (Anderson and Krathwohl, 2001). Further, learning represents a continuum of increasing cognitive complexity. Cognitive complexity can include lower-order thinking skills, such as remembering, and progress through understanding, applying, analyzing, and evaluation to higher order thinking skills, of creating (Anderson and Krathwohl, 2001). Bloom’s taxonomy encourages instructors to develop learning objectives represented by the knowledge dimension and the cognitive process dimension, and then develop relevant activities to test this knowledge. Based upon the research to date, only one paper studied the relationship between the types of activities instructors use to develop, and then test that knowledge in business courses. Specifically, the instructors noted that required homework is insignificant in developing cognitive abilities for multiple choice exam questions (Peters et al., 2002).

The primary purpose of this paper is to investigate whether or not there are differences among traditional homework methods (paper-and-pencil) and online homework software that is often packaged with textbook purchases. Publishing companies cite the repetition that is offered through online programs as a positive aspect to student’s learning techniques. As noted above, results appear to be mixed. Given the implied maturity of graduate students, should quantitative cognitive development be suggested or required? Are there differences in performance when students use traditional pencil-and-paper approaches versus online methods to develop cognitive skills? The approach taken here is to explore the different types of questions that students are addressing, specifically, differences between open-ended versus scaffolded quantitative problems. (Note, given today’s technology, computer software programs use scaffolded problems. Open-ended problems may be developed by the instructor but cannot be graded by the computer.) To that end we, with the preliminary data collected, wish to investigate the following questions:
Research Question #1A: Do students who are required to use the textbook online software as part of their quantitative exam preparation (‘Required’) perform better than those students who may choose to use textbook online software (‘Suggested’) when answering open-ended questions?

Research Question #1B: Do students who are required to use textbook online software as part of their quantitative exam preparation (‘Required’) perform better than those students who do not use online software (‘Traditional’) when answering open-ended questions?

Research Question #1C: Do students who may choose to use online textbook online software (‘Suggested’) perform better than those students who do not use online software (‘Traditional’) when answering open-ended questions?

Research Question #2A: Do students who are required to use the textbook online software as part of their quantitative exam preparation (‘Required’) perform better than those students who may choose to use textbook online software (‘Suggested’) when answering scaffolded questions?

Research Question #2B: Do students who are required to use textbook online software as part of their quantitative exam preparation (‘Required’) perform better than those students who do not use online software (‘Traditional’) when answering scaffolded questions?

Research Question #2C: Do students who may choose to use online textbook online software (‘Suggested’) perform better than those students who do not use online software (‘Traditional’) when answering scaffolded questions?

METHOD

Three sections of a graduate-level introduction to operations management course in the masters of business administration program at the same AACSB accredited institution in the northeast participated in the study. Each section made use of the same textbook. The learning objectives of the course include:

- **MBA graduates will understand global operations, management, and marketing concepts.** Explain how value is created and managed through the product lifecycle, marketing mix and structure, and value of a supply chain and its members in a dynamic environment.
- **MBA graduates will apply quantitative methods in accounting, finance, statistics, and management science.** Master quantitative applications to (a) collect data, conduct and interpret statistical analyses, (b) prepare clear business reports explaining the data, analytical methods, and results, and (c) interpret such reports written by others.

A different instructor taught each section of the course, and in keeping with academic freedoms, each instructor developed a different syllabus. Each section was taught using the traditional face-to-face method. However, for this course, the instructors agreed upon the required and optional
topics relevant to operations management that were to be included. A listing of these topics is shown in Table 1.

**TABLE 1. REQUIRED AND OPTIONAL COURSE COVERAGE**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Required</th>
<th>Topic</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operations &amp; Competitiveness</strong></td>
<td>Required</td>
<td><strong>Lean Systems</strong></td>
<td>Required</td>
</tr>
<tr>
<td>Operations &amp; SCM</td>
<td>Required</td>
<td><strong>Supply Chain Design</strong></td>
<td>Required</td>
</tr>
<tr>
<td>Competitive Weapon</td>
<td>Required</td>
<td><strong>Inventory Management</strong></td>
<td>Required</td>
</tr>
<tr>
<td>Competitive Priorities</td>
<td>Required</td>
<td>Basic Economic Order Quantity</td>
<td>Required</td>
</tr>
<tr>
<td>Globalization</td>
<td>Required</td>
<td>Periodic Order Quantity</td>
<td>Optional</td>
</tr>
<tr>
<td>Breakeven</td>
<td>Required</td>
<td>Quantity Discount</td>
<td>Optional</td>
</tr>
<tr>
<td><strong>Process Strategy</strong></td>
<td>Required</td>
<td>Safety Stk: variable demand / lead-time</td>
<td>Optional</td>
</tr>
<tr>
<td>Layout</td>
<td>Optional</td>
<td>Continuous vs. Periodic Systems</td>
<td>Required</td>
</tr>
<tr>
<td>Time Study</td>
<td>Optional</td>
<td><strong>Forecasting</strong></td>
<td>Required</td>
</tr>
<tr>
<td><strong>Process Analysis</strong></td>
<td>Required</td>
<td>Key Decisions on Making forecasts</td>
<td>Required</td>
</tr>
<tr>
<td>Quality and Performance</td>
<td>Required</td>
<td>Qualitative/Quantitative/Judgmental</td>
<td>Required</td>
</tr>
<tr>
<td>Cost of Quality</td>
<td>Required</td>
<td>Causal Models</td>
<td>Optional</td>
</tr>
<tr>
<td>Total Quality Management</td>
<td>Required</td>
<td>Time Series Concepts &amp; Calculations</td>
<td>Required</td>
</tr>
<tr>
<td>Six Sigma</td>
<td>Required</td>
<td>Seasonality</td>
<td>Required</td>
</tr>
<tr>
<td>Statistical Process Control</td>
<td>Required</td>
<td>Forecast Errors: MAD/MSE</td>
<td>Required</td>
</tr>
<tr>
<td>Process Capability</td>
<td>Required</td>
<td>Forecast Errors: MAPE</td>
<td>Optional</td>
</tr>
<tr>
<td>Quality Gurus</td>
<td>Optional</td>
<td><strong>Operations Planning &amp; Scheduling</strong></td>
<td>Required</td>
</tr>
<tr>
<td><strong>Capacity Planning</strong></td>
<td>Required</td>
<td>Aggregate Planning concepts</td>
<td>Required</td>
</tr>
<tr>
<td>Basic capacity calculations</td>
<td>Required</td>
<td>Aggregate Planning calculations</td>
<td>Optional</td>
</tr>
<tr>
<td><strong>Constraint Management</strong></td>
<td>Required</td>
<td>Scheduling Concepts</td>
<td>Required</td>
</tr>
<tr>
<td>Bottleneck</td>
<td>Required</td>
<td>Scheduling Calculations</td>
<td>Optional</td>
</tr>
<tr>
<td>Theory of Constraints</td>
<td>Required</td>
<td><strong>Material Requirements Planning</strong></td>
<td>Required</td>
</tr>
<tr>
<td>Line balancing</td>
<td>Optional</td>
<td>Low level coding</td>
<td>Required</td>
</tr>
<tr>
<td>Bottleneck Calculations</td>
<td>Optional</td>
<td>Explosion</td>
<td>Required</td>
</tr>
</tbody>
</table>

The first section, ‘Suggested’ (taught by Instructor 1) used the required book and required the use of the textbook’s online software tool to administer quizzes. Quizzes, given periodically throughout the semester, tested conceptual material through true-false questions - and not quantitative material, and counted toward 10% of the course grade (with the best 5 of 6 used to calculate final quiz grade). Students could also choose to use the publisher software to practice problems online. Problems were assigned after each applicable lecture where similar problems were demonstrated by the instructor during class. Static (problems that matched the textbook exactly) and algorithmic (problems whose numbers changed from those in the textbook) were assigned. For the online homework assignments, between 4 and 11 problems (static and algorithmic) were assigned. A total of nine (9) sets of practice problems were available through the online program throughout the semester. The practice problems did not count as part of the course grade, and students were not limited in the number of attempts at each problem. The incentive for the students to perform the practice problems is that they would prepare the student for the midterm and final exams. The two exams counted for 55% of the course grade and
computational problems, such as those reinforced by online software’s practice problems, constituted 40% of those exams. That is, computational problems counted as 40% of each exam.

The second section, ‘Required’ (taught by Instructor 2) used the required book and required students to use the same online software tool as the ‘Suggested’ section. However, the online software was only used to complete the required 9 homework assignments throughout the semester – and not in-class quizzes. Each online assignment consisted of 2 to 4 questions (potentially with sub-sections) that specifically corresponded to material covered the prior week, were 100% quantitative, scaffolded, and corresponded to similar book problems. (Students could choose to attempt other problems associated with each chapter, but it was completely voluntary on their part.) Homework was due on the evening prior to a quiz covering the same material. (Note the instructor has the ability to add customized quantitative and qualitative questions; however, this was not done for any assignment.) Homework took the student roughly 20 to 40 minutes to complete and represented 5% of the student’s final grade. Additional suggested problems were available on the institution’s learning management system, and the instructor encouraged students to review these prior to attempting the online homework. The online software was set such that the students had three tries on each problem, problems were algorithmic not static, students were given an unlimited time to complete the homework by the required due date (which corresponded to an upcoming quiz and recently taught materials), and could not print out the homework to work off line. Student evaluation also consisted of corresponding quizzes (31% with 2 out of 10 quizzes dropped) that followed homework due dates, and two exams (32% each). Quantitative material counted for approximately 33% of the in-class quiz score and 34% of the midterm exam.

The third section of the course, ‘Traditional’ (taught by instructor 3) used the same textbook, but did not use computer-based homework assignments. In fact, there was no graded homework in the course. Students received a handout that contained nine suggested problems for quality control and four for breakeven analysis, a common practice for each quantitative topic. The instructor provided full solutions to suggested problems to the students. Quantitative material was 35% of the midterm exam.

To test the value of homework – Required online, Suggested online or Traditional, as well as the different types of potential homework problems (open-ended versus scaffolded), the instructors agreed to 2 common questions on the midterm and on the final exam (forthcoming). For each course section the midterm included a common open-ended statistical process control question (Appendix 1) and a common scaffolded break-even question (Appendix 2). Similarly, two common questions agreed upon by the instructors will be included on the final (forthcoming). The instructors agreed on a common rubric (included in the figures) and performed further analysis to test for rater bias and inter-rater reliability.

RESULTS

Each instructor administered midterm exams at the approximate midpoint of the semester. Upon completion of the exams, each instructor copied the appropriate questions and provided them to the other instructors for their independent evaluation. Upon completion of the evaluation, the instructors compiled the scores for each of the sections on an Excel spreadsheet.
Analysis began by testing the effective reliability of the judges using a technique suggested by Rosenthal and Rosnow (1991). The formula for the effective reliability of judges is:

\[ R = \frac{n\bar{r}}{1 + (n - 1)\bar{r}} \]  

(1) 

where \( R \) is the effective reliability, i.e. the reliability of the total set of judges, \( n \) is the number of judges and \( \bar{r} \) is the mean correlation among all the judges (Rosenthal and Rosnow, 1991). Initial-effective and post-effective reliability analysis occurred. For the post-reliability test, the instructors met to discuss differences in the interpretation and scoring of the exams. When an instructor’s score for a particular student differed by more than 1 point, a review of the scoring for that particular student’s question occurred. Out of the 93 students, twelve (13%) of the open-ended and six (6.5%) of the scaffolded questions required a review. Initial and Post-effective Reliability test for the open-ended (Table 2) and scaffolded (Table 3) questions indicate that both the initial and post inter-rater reliabilities are excellent (\( R > .90 \)).

**TABLE 2: INITIAL AND POST EFFECTIVE RELIABILITY OF THE JUDGES: OPEN-ENDED QUESTIONS**

<table>
<thead>
<tr>
<th>Instructor</th>
<th>1 &amp; 3</th>
<th>1 &amp; 2</th>
<th>2 &amp; 3</th>
<th>( \bar{r} )</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.963</td>
<td>0.911</td>
<td>0.947</td>
<td>0.940</td>
<td>0.979</td>
</tr>
<tr>
<td>B</td>
<td>0.976</td>
<td>0.990</td>
<td>0.991</td>
<td>0.986</td>
<td>0.995</td>
</tr>
<tr>
<td>C</td>
<td>0.978</td>
<td>0.956</td>
<td>0.963</td>
<td>0.966</td>
<td>0.988</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructor</th>
<th>1 &amp; 3</th>
<th>1 &amp; 2</th>
<th>2 &amp; 3</th>
<th>( \bar{r} )</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.986</td>
<td>0.991</td>
<td>0.987</td>
<td>0.988</td>
<td>0.996</td>
</tr>
<tr>
<td>B</td>
<td>0.989</td>
<td>0.996</td>
<td>0.993</td>
<td>0.993</td>
<td>0.998</td>
</tr>
<tr>
<td>C</td>
<td>0.986</td>
<td>0.983</td>
<td>0.988</td>
<td>0.986</td>
<td>0.995</td>
</tr>
</tbody>
</table>

**TABLE 3: INITIAL AND POST EFFECTIVE RELIABILITY OF THE JUDGES: SCAFFOLDED QUESTIONS**

<table>
<thead>
<tr>
<th>Instructor</th>
<th>1 &amp; 3</th>
<th>1 &amp; 2</th>
<th>2 &amp; 3</th>
<th>( \bar{r} )</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.946</td>
<td>0.899</td>
<td>0.935</td>
<td>0.927</td>
<td>0.974</td>
</tr>
<tr>
<td>B</td>
<td>0.950</td>
<td>0.946</td>
<td>0.973</td>
<td>0.957</td>
<td>0.985</td>
</tr>
<tr>
<td>C</td>
<td>0.931</td>
<td>0.990</td>
<td>0.936</td>
<td>0.952</td>
<td>0.984</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructor</th>
<th>1 &amp; 3</th>
<th>1 &amp; 2</th>
<th>2 &amp; 3</th>
<th>( \bar{r} )</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.982</td>
<td>0.988</td>
<td>0.983</td>
<td>0.985</td>
<td>0.995</td>
</tr>
<tr>
<td>B</td>
<td>0.983</td>
<td>0.978</td>
<td>0.975</td>
<td>0.979</td>
<td>0.993</td>
</tr>
</tbody>
</table>
To test the differences between treatments (Required, Suggested and Traditional) a one-tailed $t$-test used the average score for each student for each question-type (open-ended and scaffolded) (Table 4). With respect to scaffolded questions (Table 5), student performance does not differ by treatment. Hence, research questions 1A, 1B and 1C are all insignificant, that is, there is no significant difference in student performance between Required, Suggested and Traditional performance. However, significant differences result when comparing open-ended questions (Table 6). Specifically, Required student performance differs significantly from Traditional student performance (.001; research question 2B), and Suggested student performance differs significantly from Required student performance (.034; research question 2A).

### TABLE 4. AVERAGES (STANDARD DEVIATION) BY TREATMENT AND QUESTION TYPE (MIDTERM)

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Suggested</th>
<th>Required</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaffolded</td>
<td>9.30 (1.52)</td>
<td>8.96 (1.92)</td>
<td>9.59 (1.01)</td>
</tr>
<tr>
<td>Open-ended</td>
<td>7.79 (2.30)</td>
<td>6.43 (3.09)</td>
<td>8.62 (2.17)</td>
</tr>
</tbody>
</table>

### TABLE 5. T-TEST COMPARISON SCAFFOLDED QUESTIONS SIGNIFICANCE BY TREATMENT.

<table>
<thead>
<tr>
<th>Scaffolded Questions</th>
<th>Required</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested</td>
<td>.226</td>
<td>.191</td>
</tr>
<tr>
<td>Required</td>
<td>-</td>
<td>.054</td>
</tr>
</tbody>
</table>

* $p < .05$

### TABLE 6. T-TEST COMPARISON OPEN-ENDED QUESTIONS, SIGNIFICANCE BY TREATMENT

<table>
<thead>
<tr>
<th>Open-ended Questions</th>
<th>Required</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested</td>
<td>.034*</td>
<td>.061</td>
</tr>
<tr>
<td>Required</td>
<td>-</td>
<td>.001*</td>
</tr>
</tbody>
</table>

* $p < .05$

To complete this study, on the final exam the instructors will analyze one open-ended question and one scaffolded question in the same manner as described above.

### DISCUSSION

The purpose of this research is to add to the growing literature regarding traditional homework problems and the use of online software for homework problems and its effect on student test performance. The results indicate that students, who prepare for exams using traditional preparation methods (Traditional), suggested online problems (Suggested) or required online
problems (Required) do not differ on exam performance for scaffolded types of questions. However, treatments result in significantly different student performance when student testing uses open-ended questions.

While these comments are preliminary, differences may be explained with the fact that the online software poses scaffolded problems by design. When using this software, the user is prompted for certain information and answers as they navigate the problem. This is truly a scaffold type of problem. However this does not fully explain the mixed results obtained for the open-ended question type. The results clearly note a significant difference between students who do not use the software at all (Traditional) and those who are required to use the online homework (Required). However, the significant difference between those who may use the software (Suggested) and those students that are required to use the software (Required) is more difficult to explain. Further analysis into the Suggested group to differentiate students who actually use the software, their performance on these problems and relationship to the output versus those who do not may assist in explaining the differences.

Other explanations as to the significant differences may be: differences between instructors; differences in students between treatments; and a potential false sense of security arising from a student’s use of software. With respect to instructors, the instructors taught for 8 (Suggested), 20 (Required) and 24 (Traditional) years. The Required and Traditional instructors together have 7 graduate instructional awards between them. As for student differences, Suggested and Traditional students are part of the part-time evening program at the institution. Part-time students typically take 2 to 3 courses over a semester. The third section, Required, is part of the daytime, full-time program that mainly serves one-year MBA students. The research team speculates that technology may offer a false sense of security to the students who utilize it. An end-of-semester student survey may confirm or refute this speculation. These potential explanations need further exploration.

While these results are preliminary and require more analysis (as will be given at the Conference), current results indicate a difference in student performance between online and in-class testing by testing format by treatment. Students required to use the online software to prepare for in-class test questions do not perform as well as other methods for open-ended questions, but they perform equally as well for scaffolded questions.

**APPENDIX 1 MIDTERM, OPEN-ENDED QUESTION, SOLUTION AND RUBRIC**

A bottling machine fills bottles with red fountain pen ink. An employee collects three samples, each with four observations, of the amount of ink filled in a bottle by the machine. The data collected, in milliliters of ink, is given below.

Sample #1: 50.9, 51.5, 49.6, 49.1
Sample #2: 49.0, 49.1, 49.0, 49.5
Sample #3: 51.0, 51.2, 51.4, 49.6

Is the process in control for 3-sigma limits? Show all work.
SOLUTION
R_1 = 2.4; R_2 = 0.5; R_3 = 1.8. Thus, average range = 1.566
Sample means: for sample 1 = 50.275; for sample 2 = 49.15; for sample 3 = 50.8
Grand mean, or process mean = 50.075

Range Chart:
Sample size = n = 4. So, D_4 = 2.28 and D_3 = 0.
UCL_R = D_4 x (average range) = 2.28 (1.566) = 3.570
LCL_R = D_3 x (average range) = 0 (1.566) = 0

Process is in control for range chart.

Mean chart:
Sample size = n = 4. So, A_2 = 0.73
UCL = Process mean + (A_2)(average range) = 50.075 + (0.73)(1.566) = 51.218
LCL = Process mean - (A_2)(average range) = 50.075 - (0.73)(1.566) = 48.931

Process is in control for mean chart.

Thus, we can say that the process is in control.

RUBRIC
Total = 10 points.

Range Chart: 1 point each for average range, UCL, and LCL. [3]
Mean Chart: 1 point each for process mean, UCL, and LCL. [3]
Correctly interpret range chart: 2 points, 1 for calculation and 1 for interpretation [2]
Correctly interpret mean chart: 2 points, 1 for calculation and 1 for interpretation [2]
Choose p or c chart: get zero credit in problem
If student calculates X-bar values: 1 point
Wrong n: minus 1.5
Minus 0.5 for each calculation error
Minus 1 for using individual data points rather than X-bar values in determining if the process is in or out of control.

APPENDIX 2 MIDTERM, SCAFFOLDED BREAK-EVEN QUESTION AND RUBRIC

A firm’s manager must decide whether to make or buy a certain item used in the production of microwave ovens. Making the item would involve annual equipment leasing costs of $200,000. Cost and volume estimates are as follows:

<table>
<thead>
<tr>
<th></th>
<th>MAKE</th>
<th>BUY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual fixed cost</td>
<td>$200,000</td>
<td>None</td>
</tr>
<tr>
<td>Variable cost per unit</td>
<td>$40</td>
<td>$60</td>
</tr>
<tr>
<td>Annual volume (units)</td>
<td>16,000</td>
<td>16,000</td>
</tr>
</tbody>
</table>
(a) Given these numbers, should the firm make or buy this item?
(b) At what volume would the manager be indifferent between making and buying?
(c) What is the total cost for the volume in (b)—that is, at the point at which the manager is indifferent between making and buying?
(d) A new forecast indicates that annual demand will be 25,000 units. What should the manager do—make or buy—and why?
Show all work.

SOLUTION
(a) TC for MAKE = FC + VC = 200,000 + (40)(16,000) = $840,000
    TC for BUY = FC + VC = 0 + (60)(16,000) = $960,000
    The firm should MAKE.
(b) 200,000 + 40Q = 60Q, which results in Q = 10,000
(c) Total cost in (b) = 60Q = 60(10,000) = $600,000
(d) TC for MAKE = FC + VC = 200,000 + (40)(25,000) = $1,200,000
    TC for BUY = FC + VC = 0 + 60(25,000) = $1,500,000
    The firm should MAKE.

RUBRIC
Total = 10 points.
(a) 1 point each for TC-Make, TC-Buy and for the interpretation of these values. [3]
(b) 1 point for correctly setting up the equation, and 1 point for solving it. [2]
(c) 1 point for correctly setting up the equation, and 1 point for solving it. [2]
(d) 1 point each for TC-Make, TC-Buy and for the interpretation of these values. [3]
   -- Minus 0.5 point for each calculation error.

REFERENCES


Rosenthal and Rosnow

