JET
**The Journal of Effective Teaching**
*an online journal devoted to teaching excellence*

# The Impact of Using Randomized Homework Values on Student Learning

Victor Berardi[1]
*Kent State University at Stark, North Canton, OH 44720*

**Abstract**

Much of the recent research on homework focuses on using online, web-based, or computerized homework systems. These systems have many reported capabilities and benefits, including the ability to randomize values, which enables multiple attempts by a student or to reduce academic dishonesty. This study reports on the impact of using randomized versus static homework values on student learning as measured by student performance on similar exam questions. Results indicate randomization can have a significant practical and statistical impact on improving exam scores, can reduce the rate of cheating, and can make homework a more accurate measure of student ability as the difference between homework scores and exam scores is reduced.

**Keywords:** Randomized homework, academic dishonesty, improved learning.

When looking at the history of research into the efficacy of homework for learning, the only thing clear is how muddy the results are. The concern with whether homework is helpful or not to student learning has been researched for decades without resulting in an agreement on its pedagogical value. Cooper (1989) is an important early review paper on the efficacy of homework for improving learning. In well-designed studies that controlled for homework versus no homework, though, only 70 percent showed a positive benefit of homework with high school students receiving more benefit than elementary students. Follow-up studies (Cooper & Valentine, 2001; Cooper, Robinson, & Patall, 2006), meanwhile, have found the grade level effect was still pronounced, that homework generally has a positive or at least nonnegative impact, but that there is still “no strong evidence” (Cooper et al., 2006) between the homework and achievement link. The authors suggest, after all these years, future research is still needed as most research into homework has used overly complex models that cause potential confounding of results (Trautwein & Koller, 2003; Cooper et al., 2006).

While the majority of research into homework focuses on K – 12 students, results at the college level are similarly conflicting. In my area of business education, a frequently cited study by Rayburn and Rayburn (1999) in a managerial accounting course showed consistent improvement on exam performance for those completing quantitative homework compared to those who did not. Peters, Kethley and Bullington (2002), meanwhile, reports that requiring homework in an operations management (OM) course did not im-

[1] Corresponding author's email: vberardi@kent.edu

prove results on quantitative exam problems and may have had a slight negative effect on overall performance. Peters et al. (2002) surmise that in their study students in the graded homework group adopted a "zero-sum game" mentality at the end of the semester, figuring they had already put in enough of their effort into the course. Furthermore, they note that the exam problems were multiple-choice and may have been too different from the quantitative, problem-solving homework structure to detect performance differences. I found the Peters et al. (2002) results intriguing because I teach OM at a regional campus in the mid-west where in our program OM is an upper-division, core business course taken by all business majors. I had been assigning homework problems in the course, yet too often, performance on exams in my classes would fail to impress.

Interestingly enough, while the case for homework at all levels is still far from clear, much of the homework research since Peters et al. (2002) has introduced yet another factor into the equation: technology. Using or comparing online, web-based and computerized homework systems for quantitative problems to traditional approaches has gained favor. Computer-based systems can be useful for instructors (Heizer, Render, & Watson, 2009), can positively impact student perceptions and efforts in a course (Smolira, 2008), can be particularly impactful for low-motivated students (Peng, 2009), and can help students self-regulate themselves for learning (Hauk & Segalla, 2005). For example, randomized homework values can make copying answers more difficult or allow multiple attempts, where each attempt is different so memorization does not occur. Then, immediate feedback can be given through automatic grading. With capabilities such as these, positive impacts on learning should follow, right?

Unfortunately, conflicting results still appear to be the norm. In math and science, for example, several studies (e.g., Affouf & Walsh, 2007; Zerr , 2007; Burch & Kuo, 2010) find positive impacts of utilizing this homework technology while others (e.g., Bonham, Deardorff, & Beichner, 2003; Allain & Williams, 2006; Demirici, 2007; Kodippili & Senaratne, 2008) do not.

In my area of business education, Palocsay and Stevens (2008) investigates the effectiveness of web-based homework in teaching undergraduate business statistics. While some performance improvements were seen, the variability in instructors and student ability led to the conclusion that homework technique, including data randomization, had little impact.

Heizer, Render, and Watson (2009), on the other hand, report positive impact in using web-based systems in their graduate and undergraduate operations management classes. On homework assignments, scores improved by 17 to 35 percent through multiple attempts using the web-based Prentice-Hall Grade Assist (PHGA) program. In an MBA program, improvement for the group using the PHGA system over the control group as measured by final grade average was nearly 10 points. In addition to improvements in student learning, the authors note gains in efficiency and integrity in grading along with the possibility to lessen academic dishonesty due to randomization of questions and data values.

Rapid development of commercially available homework systems is welcomed even if the jury is still out on how to best use them. For example, like Peters et al. (2002), I was not seeing benefits of using homework on student performance. Unlike Peters et al. (2002), though, my homework problems were very similar to the exams and yet too often students who earned a high score on a homework assignment would suffer a large performance drop, or gap, on similar exam problems. For example, students averaged nearly a 20 point drop on the exam for the same problem type that they had seen on the homework assignment. This large drop occurred even though many students had earned a 100 on the homework. Not only did these results bring into question the value of requiring graded homework, but it pointed to the likelihood that some students were simply copying homework answers.

When I surveyed students about academic dishonesty on assignments as part of the anonymous end-of-semester student evaluation process, though, only a couple students admitted seeing others copy work and none admitted it for themselves. Students may not have been comfortable acknowledging the existence of copying answers but the performance data indicated otherwise.

Indeed, research into academic dishonesty has shown more than 40 percent of students at all institutions acknowledged copying homework assignments and nearly 80 percent acknowledge seeing or participating in some kind of cheating (McCabe & Trevino, 1993). How prevalent academic dishonesty is for business students compared to other college students is a matter of contention, though. A study by Iyer and Eastman (2006) indicates it is lower while McCabe, Butterfield, and Trevino (2006) show a higher rate. Overall, contextual influences on academic dishonesty find factors such as membership in fraternities and sororities, peer pressure, gender, year in school, pressure to achieve, individualization, and perceptions among students about the acceptance and rate of cheating are seen to be important (Davis, Grover, Becker, & McGregor 1992; McCabe & Trevino, 1997; Pulvers & Diekhoff, 1999; Whitley & Keith-Spiegel, 2002).

While understanding these influences is instructive, for the individual teacher, how to effectively minimize dishonesty so true learning can be achieved is arguably most important. In my case, moral appeals and denoting the extent to which students were allowed to discuss the assignments (Whitley & Keith-Spiegel, 2002) were already being made. Furthermore, the assignment values were being changed for each class (Whitley & Keith-Spiegel, 2002) and yet these efforts were being met with limited success. Hence, I was motivated to develop and implement a randomized data approach with the hope it would help. With no commercial systems meeting my exact needs, I developed my own system using capabilities found in Microsoft Office.

In summary, the primary motivation behind the randomized homework approach is to improve learning as measured by student ability to solve similar problems under controlled exam conditions. A major concern was that a large performance gap existed for some students in the course where exam scores on similar problems were much lower than on their homework. This implied that whatever efforts students made or interactions they had with static homework values; it was not being translated into individual performance on exams. As a result, the potential benefit homework could have on learning was not being fully realized. A more targeted design than employed by others (e.g., Peters et al., 2002; Palocsay & Stevens, 2008; Heizer et al., 2009) was developed to avoid confounding results (Cooper et al., 2006). In particular, the design required not only looking at changes in the overall performance on exam problems and homework scores but in matching individual student homework scores directly to their related exam problems. While the study reported in this manuscript has a design that extends the important foundation work of Peters et al. (2002) and Heizer et al. (2009) in the operations management area, it should have applicability to other quantitative, problem-solving courses and be independent of implementation platform.

The remainder of the paper details my efforts to implement and study randomized homework. First, the hypotheses developed for the investigation are discussed, which is followed by experimental design considerations. Then, details on the homework assignments, including generation and grading considerations are covered. Finally, the results are presented and discussed, including limitations of the study and future considerations.

## Hypotheses

### *H1: Student Exam Performance*

The first objective is to improve student performance on exam questions of the same problem types as found on the homework assignments. This objective is measured via hypothesis H1, which states that student performance on exam problems will improve after implementing randomized homework assignments.

Exams in the course included multiple choice questions, calculation problems with related analysis questions, and essays. The multiple choice questions are almost exclusively qualitative in nature and serve to monitor general concept understanding and to check completion of reading assignments. The majority of point values on exams, however, is associated with calculation problems and related analysis questions.

To measure H1, only the exam calculation problems and analysis questions related to a homework assignment are evaluated. This avoids confounding performance results with concepts and question structures unrelated to homework that potentially impacted results of others (e.g., Peters, et al., 2002).

For example, the homework assignment for statistical process control (SPC) included an *x*-bar and *r*-chart application that had to be identified and calculated by the student from the descriptive information on the assignment. On exam two, a similar set of SPC problems were posed. If these problems represented 60 points on an exam, and a student earned 54 points, an exam performance of 90 percent was recorded for this study. Details on the structure of exam performance determination, especially related to efforts for maintaining consistency of measures between the control group and post-implementation students, are found in the section on experimental design.

It should be noted that the homework, whether randomized or not, always precedes the corresponding exam by at least two class periods. This is intentional so students can review their performance and seek help in advance of the exam. Furthermore, students are encouraged to bring two copies of their submission to class when the homework is due because after collecting their submission I solved it (or a randomized case of it) in class in order to provide some immediate feedback, which has been shown to improve student performance (Yourstone, Kraye, & Albaum, 2008; Smolira, 2008). Graded assignments were returned to students at the next class meeting.

***H2: Student Homework Performance***

While increasing exam performance is the desired effect, the overall performance on the homework assignments is expected to decrease. This represents the second hypothesis, H2. With randomized homework assignments, the process for students to check their work with others in ad hoc fashion is more complex and requires significant understanding and effort. Students who forget or procrastinate do not have an easy way to simply acquire the correct answers, which should lead to lower homework scores as postulated in H2. Related to this, it was believed that much of the decrease in homework scores would be from students who achieved a perfect homework score before randomization but not because of their own understanding. Therefore, the percentage of students earning a perfect score on homework assignments before and after randomization is monitored and reported.

***H3: Reducing homework versus exam performance differences***

Perhaps the greatest motivation for developing randomized homework assignment values resulted from the observation that there were too many students getting high scores on homework assignments that subsequently performed poorly on the same material on exams. A large gap between a student's homework and exam performance certainly brings into question the value a homework assignment had for learning. Therefore, in addition to improving the overall exam scores from H1, an important objective is to reduce the individual differences between student exam and homework performance.

The third hypothesis, H3, states that the gap between homework and exam performance on a student-level basis will decrease after implementing randomized homework assignments. In effect, there will be a significant reduction in students scoring very well on homework assignments that are not being able to perform well on similar problems during the exam.

H3 is measured by looking at the difference between each student's homework score and their exam score on the same problem type. The homework score for each student was readily available as it was recorded directly in the grade book while the student's exam score was calculated as in H1. The gap between the homework score and the relevant exam performance was then calculated. For example, a student who earned a 100 on homework but only scored 90 percent on the exam material had a difference score of negative 10. H3 differs from the first two hypotheses in that H1 and H2 are measured from an overall group performance level instead of at the student level and it is expected to have strong identification power.

## Experimental Design Considerations

Several important issues were considered in the design of this evaluation. These included adopting an appropriate experimental design structure, maintaining assignment integrity, and minimizing grading inconsistencies that could bias results. The efforts addressing these issues are discussed next.

### *Experimental Design*

To evaluate the hypotheses, a pre-test/posttest experimental design is employed in this study. The pre-test period represents a control group of 63 students with static homework data while there are 94 students who received randomized values in the implementation phase. In all statistical tests, a conservative assumption of unequal variances was used even when an equal variances assumption could be justified.

There are three homework assignments: forecasting, SPC, and inventory; each corresponding to a different exam through the semester. Forecasting was on exam one, SPC on exam two, and inventory management on exam three (the non-comprehensive final exam). Similar homework assignments and exam questions were used in each phase and special precautions were used to ensure consistency and to maintain assignment integrity as will be discussed below.

### *Maintaining Assignment Integrity*

Maintaining assignment integrity is important in any teaching situation but is critical in an experimental study like this. The actual homework assignments were modified each semester regardless of whether randomization occurred or not. The problem types are the same but the actual problems differ and strict control of the questions themselves is not possible, nor attempted, given that students complete homework outside of the classroom and can easily pass copies along. Even when static values were used in the homework, the actual values were changed semester to semester. Exams, though, were controlled carefully to ensure no copies were stolen. Integrity was accomplished by not only counting the copies but in not recording student grades until after the exam was reviewed in class and all exams were verified as returned.

### *Minimizing Inconsistencies in Grading*

Another important concern was controlling the consistency of exam and homework grading. Rubrics played an important role here. Effort was made before the control phase began to standardize grading where common mistake areas were identified and point deductions were determined. These rubrics were used for both homework and exam grading to minimize inconsistencies from student to student and over time.

## Homework Assignments

This study incorporates three different homework assignments in the randomization experiment. Each assignment, which corresponds to a different exam during the semester, is detailed next. Then, information on assignment generation and the mechanics of grading with randomized data is discussed.

### *Forecasting*

The first homework assignment of the semester relates to forecasting. Students are required to develop forecasts where each student has different data series values and variability. Three forecasting methods are required including moving averages, weighted moving averages, and exponential smoothing. Forecast evaluations are made and error measures are calculated, which include bias, mean absolute deviation (MAD), and mean square error (MSE). Students must ultimately choose the best overall forecasting method, provide an explanation of why it was chosen, and answer additional questions related to the forecasting process they just completed. This is a significant effort for students, especially early in the semester. The concepts themselves are not particularly difficult but the sheer number of new issues is intimidating to students.

### *Statistical Process Control*

The second homework assignment relates to statistical process control (SPC). In this assignment, an organizational application is described and data given. Students must identify the correct chart(s), calculate the control limits, and develop the graphs. They then must answer related questions, such as to identify if the process is in-control or not. In its current form, the application is the same for all students, a variable data situation necessitating x-bar and r-charts, but the values and decisions vary in the randomization phase. For example, one student may have a process that is in-control while others have out-of-control process data.

SPC is typically the most conceptually challenging section of the course for students and considerable time is spent reviewing the probability and statistics theories that underlie the charts. While the textbook is used for theory and understanding, students use *The Memory Jogger II* (Brassard & Ritter, 1994) for implementation. This pocket reference has a decision tree students use to select the correct chart, a step-by-step guide for control chart implementation, formulas, constants, and information on how to interpret the charts. *The Memory Jogger II* is a handy reference book that students are allowed to use on exams too. SPC related questions are found on the second exam of the semester.

### *Inventory Management*

The third homework assignment relates to inventory management. As with SPC, a description of an organizational setting is provided to students along with randomized data for costs and usages. Students must identify the correct inventory model, calculate items of interest such as order quantity, reorder point, and total cost, and then answer related questions. Inventory management is one of the last major topics of the semester and it corresponds to questions on the final exam.

### *Homework Generation*

The randomized assignments in this study are implemented using Microsoft Office and were developed by the author. It should be noted that textbook publishers have tools that can accomplish randomization that might suffice for other instructors.

In this implementation, students are sent an Excel file as an attachment to an email or given a file link to download. When the file is opened, only one spreadsheet is visible in the workbook. All other sheets and programming are hidden and password protected. A Visual Basic for Applications (VBA) macro automatically begins, which opens a dialog box prompting the student to enter his/her name and the last four digits of his/her student identification (ID) number. Error checking routines are employed to ensure all four values are entered and that they are indeed numbers and not letters or other characters. Those interested learning more about coding in VBA should find Walkenbach (2007) is an accessible, yet comprehensive, resource.

The ID is used to generate the randomized values for each student where a minimum of 1000 cases are created for each. The student ID is then scrambled before being used to generate data, where a different ID pattern is used for each assignment to make it improbable that two students could have the same or similar values for multiple assignments.

Each case for an assignment has both a systematic adjustment and a random error component. For example, in a forecasting assignment, an initial pattern was developed and a systematic adjustment was used to shift the cases in scale, going from several hundred units in some cases to several thousand units in others. Then, a random adjustment was added to the individual values so the pattern would show variability and not simply be a shift that could be readily identified through graphing.

This approach facilitates the ability to have differing decisions from student to student based upon the specific case data. As a result, not only do the values differ but the analysis and conclusions can vary too. This was explained to students so they would understand it, get over it, and focus on making decisions consistent with what the data indicated was correct for their case without regard, or fear, for what others may have been seeing.

### *Grading of Student Assignments*

One of the significant concerns with using randomized assignments for student homework is how to grade efficiently when the values are different for each case. Indeed, at the 2009 Decision Sciences Meeting in New Orleans, several of the publisher offerings for randomized or internet-based homework systems presented in break-out sessions emphasized instructor efficiency given automatic grading capabilities. While the prime motivation in this study is to determine if randomized assignment values do indeed improve student learning without regard to implementation platform, automatic grading via publisher offerings is an added bonus for instructors with large section sizes.

On my campus, section sizes are kept below 35 students, so maintaining the connection and feedback obtained from personally grading student assignments as part of teaching reflection is still possible. To facilitate the individualized grading key, a solution worksheet was created in the Excel workbook for each assignment. This sheet initially was used for error checking the systems and for reviewing the development of the student cases in each assignment. This worksheet was deleted from the file given to students but it was used in conjunction with the roster and simple looping logic to develop customized solution sheets for each student. These were aggregated into a class key.

The main grading efficiency loss came from the fact that memorizing the correct answers was not possible. However, with good grading key structure, just a little extra time, perhaps 20 to 25 percent, was needed. Of course, online and publisher-based grading tools will further reduce or eliminate efficiency concerns for those interested in using randomized assignment values in their courses.

## Results and Discussion

The first hypothesis, H1, tests if student performance on exams improved during the randomized homework phase of the study. In figure 1, it is seen that exam performance increased by 3.83 (*p*-value = .083), 3.63 (*p*-value =.038), and 2.65 points (*p*-value =.188) respectively on each of the three exams. Recall that the first exam covered forecasting, the second included SPC, and the third covered inventory management. Therefore, randomized homework has a statistically significant impact on the first two exams but less of a statistical effect on the third.

From a practical standpoint, it is encouraging to see improvement range from one-quarter to nearly four-tenths of a letter grade for students in the randomized homework group relative to the static homework students. Even from a theoretical standpoint, the gain achieved, as measured by Hake's gain statistic (Hake, 1998), *g*, shows that between 11 percent and 17 percent of the total gain possible is achieved simply by implementing randomized homework values. As an instructor, I was pleased with these results, especially considering that during the static data phase, the range of exam averages across the three exams was only 1.37 points, roughly one-half the impact seen from randomization. In other words, randomizing homework values led to a larger impact in student performance than a change in topics—from forecasting to SPC to inventory—had during the static data phase.

It was not initially clear why the forecasting and SPC topics had a greater improvement than the inventory material; however, viewing the results in terms of the end-of-semester gaming phenomenon, where students seek to maximize their grades across courses as posited by Peters et al. (2002), sheds light on the issue. For example, students who have done well in a course and built up a cushion going into the final exam might put more effort into their other courses, resulting in uncharacteristically low scores on the final exam. Alternatively, students who had not performed as well on prior exams, but who still wanted to improve their course grade, could be expected to show relative improvement on the final exam. Fortunately, the data give some insights into this phenomenon.

First consider the exam scores for the students who earned 100 percent on at least one of the first two exams. On average, these students scored 93.8 percent on the first two exams but only 81.5 percent on the final exam. Hence, students who had scored the highest on the earlier exams dropped 12.3 points on the final exam to just a few points above the class average. At the same time, of the students who earned a 100 percent on the final exam, none had earned a 100 on an earlier exam. In fact, these students had averaged only a 78.8 percent on the first two exams, below the average. Both of these results support the proposition that external end-of-semester issues were at play. As an instructor, it is particularly satisfying to see students who had struggled on earlier material rise up to achieve on the final exam.

**Figure 1. Data for hypothesis H1: performance on exams will increase with the use of randomized homework assignments.**

| | Exam 1 (Forecasting) | | Exam 2 (SPC) | | Exam 3 (Inventory) | |
|---|---|---|---|---|---|---|
| | pre-random | post-random | pre-random | post-random | pre-random | post-random |
| **Mean** | 77.47 | 81.30 | 76.39 | 80.02 | 76.10 | 78.75 |
| **Variance** | 304.9 | 255.0 | 118.0 | 208.5 | 385.1 | 223.7 |
| **Obs.** | 63 | 94 | 63 | 92 | 60 | 90 |
| **t-statistic** | -1.39 | | -1.79 | | -0.89 | |
| **p-value** | 0.083 | | 0.038 | | 0.188 | |

The second hypothesis, H2, measured student performance on the homework assignments where a performance decrease during the randomization phase is anticipated. In Figure 2, it is seen that homework scores decreased by 2.96 points (*p*-value = .053) on the first homework assignment, forecasting; was lower by 9.35 points (*p*-value = .000) on the second assignment, SPC; and yet increased by 2.18 points on the third assignment, inventory. The magnitude of the impact, in terms of Hake's (1998) statistic, *g*, is moderate for the forecasting ($g$ = -0.48) and inventory ($g$ = 0.37) and is strong for SPC ($g$ = -1.57).

**Figure 2. Data for hypothesis H2: performance on homework assignments will decrease with the use of randomized homework assignments.**

| | HW 1 (Forecasting) | | HW 2 (SPC) | | HW 3 (Inventory) | |
|---|---|---|---|---|---|---|
| | pre-random | post-random | pre-random | post-random | pre-random | post-random |
| **Mean** | 93.89 | 90.93 | 94.03 | 84.68 | 94.03 | 96.21 |
| **Variance** | 89.1 | 179.8 | 77.0 | 258.9 | 143.4 | 64.6 |
| **Obs.** | 63 | 94 | 63 | 92 | 60 | 90 |
| **t-statistic** | 1.63 | | 4.65 | | -1.24 | |
| **p-value** | 0.053 | | 0.000 | | 0.609 | |

Further review of the data indicates that much of this impact comes from a change in the rate of perfect homework scores after randomization. The rate of perfect scores decreased by 15.3 percent on the forecasting assignment, by 49.7 percent on SPC, while perfect scores increased by 12.2 percent on the inventory homework.

To understand the implication of this, consider the impact randomized values had on the scores. For SPC in particular, it is apparent that many of the perfect scores on the homework during the static data phase were the result of copying by students; simply giving each student unique values cut the rate of perfection in half. In the randomization phase, however, this means more students did not have a high score on the SPC homework, artificially propping up their average. As a result, doing well on the final homework assignment, inventory, became more important and students responded. So not only is the apparent rate of cheating decreased, but motivation for students to perform on the next assignment appears increased. While these results are encouraging for the class as a whole, viewing homework's effect on exam performance from an individual student perspective is more refined and discussed next.

The third hypothesis, H3, tested individual student performance gaps on homework compared to the related exam problems. Figure 3 shows a reduction in the gap between homework and exam performance on all three assignments. On the first exam, forecasting, the performance gap between the static data group and random data group is reduced by 6.8 points, from a gap of -16.4 to -9.6 (*p*-value = .006). On exam two, SPC, the difference is reduced by 13.4 points, from -17.6 to -4.2 points (*p*-value = .000). The third exam, inventory, shows a very small performance gap of 0.5 points, from a gap of -17.9 to -17.4 points (*p*-value = .438). Therefore, on the first two assignments, a significant statistical and practical reduction in individual performance gaps on homework and exam scores is achieved. On the third exam, end-of-semester gaming, as discussed under H1, appears to play a role in the near zero change in performance gap.

**Figure 3. Data for hypothesis H3: individual performance gaps on exams and homework assignments will decrease with the use of randomized homework assignments.**

| | Forecasting (HW 1 - Exam 1) | | SPC (HW 2 - Exam 2) | | Inventory (HW 3 - Exam 3) | |
|---|---|---|---|---|---|---|
| | pre-random | post-random | pre-random | post-random | pre-random | post-random |
| **Mean** | -16.4 | -9.6 | -17.6 | -4.2 | -17.9 | -17.4 |
| **Variance** | 236.8 | 322.4 | 127.9 | 301.0 | 405.8 | 231.8 |
| **Obs.** | 63 | 94 | 63 | 92 | 60 | 90 |
| **t-statistic** | -2.53 | | -5.84 | | -0.16 | |
| **p-value** | 0.006 | | 0.000 | | 0.438 | |

The improvements related to the forecasting and SPC material are considerable and warrant added discussion. Notice for the control group, the decline in exam performance on the forecasting and SPC material is 16.4 points and 17.6 points, respectively. This means that a student with static data who gets a homework score in the high 90s could struggle to achieve a low 80s score on the same material under exam conditions. While one could certainly expect to see some decrease given the control and pressure inherent in an exam situation, any instructor would be concerned by this magnitude of effect.

Once again, implementing randomized homework values had a significant practical impact in addition to a statistical one. On the forecasting material, the homework versus exam performance gap was reduced by more than 41 percent to a 9.6 point decline for the students receiving randomized homework values. For SPC, the performance gap was reduced by nearly 76 percent to a satisfyingly small 4.2 point difference. In other words, with randomized data the homework assignments have become better indicators of a student's ability to perform on the exam. And since overall exam performance increased per H1, student learning, as measured by performance on the same material at a later point in time under controlled conditions, appears improved.

## Conclusion and Future Work

While the design used in this study was necessarily tailored to the issues as they pertained to homework in an established operations management course, the randomized homework approach and lessons learned should be applicable to other quantitative courses. In this study, exam scores increased when using randomized homework values compared to using static values, thereby supporting hypothesis H1. Student homework scores decreased as postulated in H2, where much of this drop was due to a lower rate of perfect scores on homework after randomization. On one assignment, perfect scores dropped by nearly 50 percent, which indicates that in the static data phase many students were probably just copying answers. Finally, with randomized values, homework scores became a more accurate reflection of student ability as the gap between homework and exam scores was reduced per hypothesis H3.

Randomized values are not a panacea, though, as external factors affecting student performance can be significant. In particular, end-of-semester concerns by students who are trying to maximize their grades across several courses are not trivial. On the positive side, it was seen that the students who perform best on the final exam were those who struggled near the class average earlier in the semester. At the same time, high performing students may still suffer a drop-off as they focus their energies on other courses. Investigating the impact of semester timing on performance by randomizing topic sequencing would be a significant study to conduct in itself. To do so in a meaningful timeframe would require having several sections of a course offered simultaneously so assignment timing can be randomized, which is more than a small campus such as mine affords.

The randomized capabilities developed for this study or those available from publisher offerings may have even greater value for use in fully online courses. In addition to homework, problems presented on exams can include randomized data where values, and indeed problem structure, can be varied for each student. As in this current investigation, there are implications for both improving student learning and reducing academic dishonesty in online sections. This is especially important given that exams in many online courses are completed in an un-proctored environment similar to what is seen with homework from traditional courses. I have just begun teaching a fully online section of operations management and I am collecting data on the initial phase of an investigation.

## Acknowledgement

This project received support through a Kent State University Teaching Council's Teaching Development Award.

## References

Affouf, M., & Walsh, T. P. (2007). An assessment of web-based homework in the teaching of college algebra. *International Journal for Technology in Mathematics Education*, 14(4), 163 – 167.

Allain, R., & Williams, T. (2006). The effectiveness of online homework in an introductory science class. *Journal of College Science Teaching*, 35(6), 28 – 30.

Bonham, S. W., Deardorff, D. L., & Beichner, R. J. (2003). Comparison of student performance using web and paper-based homework in college-level physics. *Journal of Research in Science Teaching*, 40(10), 1050 – 1071.

Brassard, M., & Ritter, D. (1994). *The Memory Jogger II*, 1st Edition, Salem, NH.

Burch, K. J., & Kuo, Y-J. (2010). Traditional vs. online homework in college algebra. *Mathematics and Computer Education*, 44(1), 53 – 63.

Cooper, H. (1989). Synthesis of research on homework. *Educational Leadership*, 47(3), 85-91.

Cooper, H., Robinson, J. C., & Patall, E. A. (2006). Does homework improve academic achievement? A synthesis of Research 1987—2003. *Review of Educational Research*, 76(1), 1 – 62.

Cooper, H. & Valentine, J. C. (2001). Using research to answer practical questions about homework. *Educational Psychologist*, 36(3), 143 – 153.

Davis, S. F., Grover, C. A., Becker, A. H., & McGregor, L. N. (1992). Academic dishonesty: Prevalence, determinants, techniques, and punishments. *Teaching of Psychology*, 19(1), 16 – 20.

Demirci, N. (2007). University students' perceptions of web-based vs. paper-based homework in a general physics course. *Eurasia Journal of Mathematics, Science and Technology Education*, 3(1), 29 – 34.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64 – 74.

Hauk, S., & Segalla, A. (2005). Student perceptions of the web-based homework program WeBWorK in moderate enrollment college algebra classes. *Journal of Computers in Mathematics and Science Teaching*, 24(3), 229 – 253.

Heizer, J., Render, B., & Watson, K. (2009). Web-based instruction improves teaching. *Decision Line*, January, 2009, 4-6.

Iyer, R., & Eastman, J. K. (2006). Academic dishonesty: Are business students different from other college students? *Journal of Education for Business*, 81(12), 101 – 110.

Kodippili, A., & Senaratne, D. (2008). Is computer-generated interactive mathematics homework more effective than traditional instructor-graded homework? *British Journal of Educational Technology*, 39(5), 928 – 932.

McCabe, D. L., Butterfield, K. D., & Trevino, L. K. (2006). Academic dishonesty in graduate business programs: prevalence, causes, and proposed action. *Academy of Management Learning and Education*, 5(3), 294 – 305.

McCabe, D. L., & Trevino, L. K. (1993). Academic dishonesty: Honor codes and other contextual influences. *Journal of Higher Education*, 64, 522 – 538.

McCabe, D. L., & Trevino, L. K. (1997). Individual and contextual influences on academic dishonesty: A multicampus investigation. *Research in Higher Education*, 38(3), 379 – 396.

Palocsay, S. W. & Stevens, S. P. (2008). A study of the effectiveness of web-based homework in teaching undergraduate business students. *Decision Sciences Journal of Innovative Education*, 6(2), 213-232.

Peng, J. C. (2009). Using an online homework system to submit accounting homework: role of cognitive need, computer efficacy, and perception. *Journal of Education for Business*, 84(6), 263-268.

Peters, M., Kethley, B., & Bullington, K. (2002). The relationship between homework and performance in an introductory operations management course. *Journal of Education for Business*, 77(6), 340-344.

Pulvers, K., & Diekhoff, G. M. (1999). The relationship between academic dishonesty and college classroom environment. *Research in Higher Education*, 40(4), 487 – 498.

Rayburn, L. G. & Rayburn, J. M. (1999). Impact of course length and homework assignments on student performance. *Journal of Education for Business*, 74(6), 325-331.

Smolira, J. C. (2008). Student perceptions of online homework in introductory finance courses. *Journal of Education for Business*, 83(12), 90-94.

Trautwein, U., & Koller, O. (2003). The relationship between homework and achievement—still much of a mystery. *Educational Psychology Review*, 15(2), 115 – 145.

Yourstone, S. A., Kraye, H. S., & Albaum, G. (2008). Classroom questioning with immediate electronic response: do clickers improve learning? *Decision Sciences Journal of Innovative Education*, 6(1), 75-88.

Walkenbach, J. (2007). *Excel 2007 Power Programming with VBA.* Hoboken, NJ, Wiley Publishing.

Whitley, B. E., & Keith-Spiegel, P. (2002). *Academic dishonesty: an educator's guide.* Mahwah, NJ: Lawrence Erlbaum.

Zerr, R. (2007). A quantitative and qualitative analysis of the effectiveness of online homework in first-semester calculus. *Journal of Computers in Mathematics and Science Teaching*, 26(1), 55 – 73.