Revising Quantitative Assignment Policies to Improve Student Achievement in an Online Operations Management Course

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ABSTRACT

Instructors must make time to monitor and reflect on how their assignment policies support student achievement. They need to experiment with their policies and tweak them to help students learn the material. In this study, the author analyzes the quantitative assignment scores of 332 students over seven consecutive semesters in an undergraduate operations management course. The original assignment policies, characterized by generous completions times and several opportunities for revision, resulted in poor student performance. After tightening the assignment policies, the overall average of the student assignment scores increased by 15%. Data analysis using a series of t-tests revealed these results to be statistically significant with a large effect size.

Keywords: online course management, operations management, quantitative assignment policies

INTRODUCTION

This study will focus solely on the policies for quantitative assignments given to students in an online, upper-level undergraduate operations management course. These assignments comprise multiple-part problems or exercises, selected from a textbook publisher's problem bank, that students solve using mathematical models and Excel. Although there is a great deal of non-quantitative content in operations management, this study concentrates on the quantitative assignments because students find them difficult and time-consuming to complete. This operations management course is required of all business majors at the author's university, and a significant number of students enroll each semester. Typically, the author's department offers five or six face-to-face sections and one or two online sections of the course per semester. Currently, the author is the only instructor teaching the online sections; therefore, the course content and its policies are this instructor's own design. The quantitative assignments discussed in this study contribute 40% to the students' semester grade, with the remaining 60% coming from reading assignments, PowerPoint presentations, video assignments, discussions, and chapter exams. Each semester students' average final course grade is between a B and a C+. Readers should note that the author is the instructor referenced in this article.

When the instructor began teaching the course online, she established policies for the quantitative assignments that she believed would be beneficial to student success. Those policies included access to the textbook and tutorials for solving the problems, an entire week and three attempts to complete the exercises, a student-moderated Q & A discussion board, and opportunities to ask the instructor questions about solving the problems. Over the course of several semesters, the author became aware that these policies did not achieve the desired results. Instead, from semester to semester, the average homework scores were consistently lower than anticipated. Checking time and date stamps for the assignments revealed that most students waited until the due date to begin their work, leaving almost no time to ask other students or the instructor for help or to take advantage of more than one attempt to complete the exercises. The instructor wondered if her policies were, in fact, encouraging procrastination and enabling poor time management.

During the past academic year, the instructor made changes to the quantitative assignment policies in the hope that student learning and assignment scores would improve. The policy changes were developed based on student feedback from end-of-semester course evaluations, discussions with other faculty who teach online courses, and research concerning the pedagogy of teaching online. The primary policy changes focused on reducing the number of attempts and the time allowed to complete the assignments, but also giving students access to publisher-provided tools that would provide answers to their questions. The goal was to create policies that would mitigate procrastination and provide students with new resources available to them 24/7. In the discussion and conclusions sections of this article, the author will report the outcomes of the policy changes and recommendations for future policy changes, respectively.

PREVIOUS RESEARCH

In recent years, the number of courses, even entire programs, offered online has grown tremendously. Students voluntarily or involuntarily enroll in online courses. Those students who volunteer to register for online courses want the flexibility such courses can offer. While other students who prefer taking courses face-to-face, choose to enroll in online courses to avoid commuting to campus, to balance work and family commitments, and to resolve scheduling conflicts (Lee, Stringer, and Du, 2017). In other instances, students enroll in online courses because it is the only mode of delivery offered for that course (Wright and Holmberg-Wright, 2018). In this study, both modes of delivery are available for the operations management course, but many students, especially student-athletes, voluntarily register for the course online.

In the case of operations management, students may avoid taking the course online because of its content. Students, instructors, and researchers find the content of the course to be challenging. Asef-Vaziri (2015) characterizes that content as quantitative, data-driven, and analytical. Furthermore, he writes that students lack the necessary foundation to succeed in the course because they have not done well in prerequisite courses or retained the knowledge needed to succeed, namely knowledge of mathematics and statistics. Students in this author's online operations management course are sometimes surprised to discover the course has quantitative components; rather, they assume those more difficult elements will be omitted.

Lacking quantitative and analytical skills are, indeed, barriers to success. But students' lack of study and time management skills pose additional obstacles. Nicolau (2015) found evidence that students' grades suffered when they procrastinated. He tracked the lead time that students gave themselves for assignments and discovered that students who began their assignments in advance earned higher grades than those who allowed themselves less lead time. Nicolau concluded that students who waited longer to begin their work sacrificed the benefits gained from seeking feedback in advance of the assignments due date. Furthermore, Artino and Stephens (2009) also found that procrastination and poor time management impeded student success. Their research uncovered that motivation and self-regulation were necessary for students to be successful. Students demonstrated motivation by being interested in the course content, wanting to succeed, and believing that they would be able to use what they learned in other courses. Self-regulated students possessed the abilities to set their goals and manage the learning process by developing strategies to achieve those goals. According to Shaker, Nathan, and Dale (2014), one of the most effective strategies was scheduling; successful online students benefited from scheduling time to do their coursework.

The research literature makes it clear that there is a great deal of thought necessary when it comes to designing and redesigning online courses. In this study, the focus is on the redesign of an online course. According to Baran and Correia (2014), redesigning requires reflection about content, policies, and students' capabilities and behaviors. Other researchers advise instructors to select learning platforms and software that are both easy to use and support students' learning (Riley et al., 2017) as well as students' independence and autonomy (Baran, Correia, and Thompson, 2011). The author considered all of these factors when making changes to her quantitative assignment policies.

RESEARCH DESIGN

The author conducted this study, involving 332 students over seven consecutive semesters, spring 2016 through spring 2019. Each term, students completed nine quantitative assignments. While the problems assigned varied from semester to semester, the nine topics remained the same—break-even analysis, statistical quality control, project management, aggregate planning, independent demand inventory, dependent demand inventory, logistics and transportation, line balancing, and forecasting. Appendix A provides detail about the problem types assigned for each topic. The instructor created the assignments using algorithmic problems selected from the textbook publisher's problem bank; each student solved the same multi-part problems, but with data randomly generated for individual problems. Although the number of problems assigned for each topic varied, the total points awarded for each assignment was the same; therefore, no single quantitative assignment was worth more than another.

During the entire study, students learned to solve the exercises by reviewing tutorials prepared by the instructor using SoftChalk, a web-based program for authoring digital content; those tutorials included text, images, videos demonstrating how to solve the problems, and self-check quizzes. In addition to the tutorials, students were able to

reference their textbook, post questions to a student-moderated discussion board, and ask the instructor questions about solving the problems.

Data Collection

For five consecutive semesters, spring 2016 to spring 2018, the policies for completing the quantitative exercises remained the same: start dates were 12:00 a.m. Mondays and end dates were 11:59 PM on Sundays; students were allowed three attempts to complete the assignment; after submitting each attempt, their assignments were autocorrected, and the correct and incorrect answers identified; after the first and second attempts, students revised the answers to their original problems. Detailed solutions were only published after an assignment's due date. For each of the above-mentioned semesters and policies described, the average scores for each of the nine assignments were calculated and analyzed for the 236 students enrolled in the author's operations management course during this time period.

Beginning in fall 2018, the author changed the assignment policies. The quantitative assignments opened at midnight on Sundays and were due by 6:00 p.m. on Fridays, allowing students to complete the exercises and review their solutions before taking the chapter exam the next day. In addition, the students were limited to two attempts, but they were able to access hints provided by the publisher and to check their answers one time per problem. The publisher's hints, when available, were brief videos demonstrating the Excel solution to a similar problem. Students could also refer to their textbook, post questions to the discussion board, and contact the instructor for help. The 6:00 p.m. Friday due date was chosen because other students and the instructor were more likely to be available to answer questions during "regular" business hours.

At the end of the fall 2018 semester, after examining the average scores, there was evidence of improvement. However, there remained evidence that most students were not beginning to work on their exercises until the day they were due. Many still did not have a chance to ask questions or take advantage of the second attempt to revise their work. The fall 2018 assignment policies remained in effect during spring 2019 except the number of attempts was reduced to one. The author's intent was to encourage students to use their resources sooner, rather than later, on that single attempt. The number of students enrolled in the 2018-2019 academic year was 96. These policy changes raised questions. Were the average assignment scores from spring 2016 to spring 2018 different from one another? And were the means from fall 2018 and spring 2019 different from each other? Furthermore, did the changes in assignment policies affect the scores?

Data Analysis

To answer the above questions, the author conducted a series of tests of mean differences. The first analysis was to test for differences in the means of the nine quantitative assignments across five semesters, spring 2016 to spring 2018. During those terms, the same policies—three attempts and a week to complete the assignments—were in effect. A two-factor ANOVA without replication (or a randomized block design) was used to test for differences between the means; the semesters were the treatment, and the assignments were the block.

For the second analysis, because the same assignments were measured at two different times, the author used a paired t-test to check for differences between the fall 2018 and spring 2019 semester means. In these two semesters, the assignment policies reduced the time allowed and the number of attempts to complete the assignment; however, students were given the additional resources of hints and one opportunity per problem to check their answers before submitting their assignments.

The final analysis was to assess the overall means of the assignments before and after the assignment policy changes. To do this, the author averaged the mean of each assignment across the semesters prior to the policy changes, spring 2016 to spring 2018, and the semesters after the policy changes, fall 2018 and spring 2019. Once again, a paired t-test analysis examined the data for a difference in the mean percent scores before and after the policy changes.

For all three analyses, the data were assignment scores measured as percent; and the null hypotheses were that the means were equal, and the alternative hypotheses stated that the means were not equal. All analyses specified a 0.05 level of significance, and their results are presented in the next section.

DISCUSSION

The first analysis, a two-factor ANOVA without replication, investigated the difference in the mean percent scores across the five semesters before assignment policies were changed. As indicated below in Table 1, the mean assignment scores (measured in percent) did not differ significantly from semester to semester, $F(4, 32) = 0.08$, $p = 0.989$; however, there were significant differences in the means between the various assignments, $F(8, 32) = 10.50$; $p < .001$, and a medium to large effect size, $\eta^2 = .73$.

Table 1: Two-Factor ANOVA without Replication of Mean Scores for Spring 2016 to Spring 2018

Assignment	Mean	Variance
Break-Even Analysis	0.8256	0.0005
Statistical Quality Control	0.7116	0.0016
Project Management	0.7130	0.0020
Aggregate Planning	0.5271	0.0100
Independent Demand Inventory	0.5978	0.0106
Dependent Demand Inventory	0.6153	0.0014
Logistics and Transportation	0.6342	0.0086
Line Balancing	0.6979	0.0006
Forecasting	0.5181	0.0020
Spring 2016	0.6393	0.0139
Fall 2016	0.6466	0.0172
Spring 2017	0.6519	0.0137
Fall 2017	0.6557	0.0139
Spring 2018	0.6513	0.0083

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Assignments	0.3877531	8	0.0484691	10.495835	4.448E-07	2.2443961
Semesters	0.0014343	4	0.0003586	0.0776506	0.9885814	2.6684369
Error	0.1477741	32	0.0046179			
Total	0.5369616	44				

Post-hoc Tukey comparisons traced the source of the significant differences in the average assignment (percent) scores. Of the potential 36 pairwise comparisons, 11 were significant. At the 0.01 level of significance, the break-even analysis score (0.83) was significantly higher than the forecasting (0.52), aggregate planning (0.53), independent demand inventory (0.60), dependent demand inventory (0.62), and logistics and transportation scores (0.63). In addition, the mean percent scores for the project management (0.71) and statistical quality control (0.71) assignments were significantly higher than the scores for forecasting (0.52) and aggregate planning (0.53) assignments at the 0.01 level. Finally, the mean percent score for the line balancing assignment (0.70) was significantly higher than the forecasting assignment (0.52) at the 0.01 level of significance and higher than the aggregate planning assignment (0.53) at the 0.05 level.

In summary, this analysis revealed that the scores on the assignments differed significantly by assignment but not by semester. The results for the difference in the assignments did not surprise the instructor; the instructor knows from teaching operations management that some topics are more difficult than others. Additional discussion about this finding will take place in the conclusions section of this study.

The next step in the analysis was to determine whether or not there were differences in the assignment scores between the fall 2018 and spring 2019 semesters. For this purpose, the author conducted a paired t-test for the mean difference in the scores for the two semesters. The results of that analysis are presented in Table 2.

Table 2: Paired T-test of Mean Scores (percent) for Fall 2018 and Spring 2019 Semesters

Assignment	Fall 2018	Spring 2019	Difference (Fall 2018 - Spring 2019)
Break-Even Analysis	0.9403	0.9667	-0.0263
Statistical Quality Control	0.8627	0.8510	0.0117
Project Management	0.8593	0.7030	0.1563
Aggregate Planning	0.8477	0.8450	0.0027
Independent Demand Inventory	0.8113	0.8130	-0.0017
Dependent Demand Inventory	0.7593	0.7770	-0.0177
Logistics and Transportation	0.7550	0.6623	0.0927
Line Balancing	0.7503	0.7160	0.0343
Forecasting	0.7117	0.7113	0.0003
Semester Mean Scores (as percent)	0.8109	0.7828	0.0280

The above table identifies the scores for the fall 2018 assignments (M = 0.81, SE = 0.02), the spring 2019 assignments (M = 0.78, SE = 0.03), and their differences. Based on the results of the paired t-test, the average difference, 0.03, CI [-0.02, 0.07], was not significant $t(9) = 1.41$, $p = .195$, and represented a small-sized effect, $d = 0.30$.

After learning that the overall assignment scores did not differ significantly in these last two semesters, the author analyzed the scores based on the assignment policies in effect at the time the data were gathered. To do this, the author averaged the nine assignment scores across the five semesters (spring 2016 to spring 2018) when the students had an entire week and three attempts to complete the exercises and compared them to the assignment scores averaged over the last two semesters (fall 2018 and spring 2019) when students had fewer attempts and less time to complete the assignments, access to hints, and the ability to check their answers one time. These two new groups were named pre-policy change and post-policy change and tested for significant differences between the two groups using a paired t-test.

Table 3 provides the mean scores for the assignments prior to the policy changes (spring 2016 to spring 2018; M = 0.65, SE = 0.03), after the policy changes (fall 2018 and spring 2019; M = 0.80, SE = 0.03), and their differences. Note that the column of difference scores are all negative, indicating that every quantitative assignment had a higher average score after implementing the policy changes. Based on the results of the paired t-test, the average difference, 0.15, CI [-0.21, -0.08], was significant $t(9) = -5.09$, $p < .001$, and represented a large-sized effect, $d = 1.5$.

Table 3: Paired T-test of Mean Scores (percent) for Pre- and Post-Policy Changes

Assignment	Pre-Policy Change	Post-Policy Changes	Difference
Break-Even Analysis	0.8256	0.9535	-0.1279
Statistical Quality Control	0.7116	0.8568	-0.1453
Project Management	0.7130	0.7812	-0.0681
Aggregate Planning	0.5271	0.8463	-0.3192
Independent Demand Inventory	0.5978	0.8122	-0.2143
Dependent Demand Inventory	0.6153	0.7682	-0.1528
Logistics and Transportation	0.6342	0.7087	-0.0745
Line Balancing	0.6979	0.7332	-0.0352
Forecasting	0.5181	0.7115	-0.1934
Policy Mean Scores (as percent)	0.6490	0.7968	-0.1479

CONCLUSIONS

Two-Factor ANOVA without Replication for Spring 2016 to Spring 2018

Using a two-factor ANOVA without replication to study the data from spring 2016 to spring 2018, the author analyzed the performance of 236 students while the original assignment policies were in effect. From semester to semester, the overall average of the scores did not change; they were consistently disappointing. However, the analysis revealed that there were significant differences in the average scores for individual assignments. The scores for the break-even analysis, statistical quality control, project management, and line balancing assignments were higher, and the ones for forecasting, aggregate planning, independent demand inventory, dependent demand inventory, and logistics and transportation were notably lower. Based on the author's experience, students find the latter group of assignments more challenging because they must choose the appropriate mathematical model, from several, to solve the exercises. This variation in difficulty is the reason that the quantitative assignments are worth the same number of points. The author does not want students' grades affected disproportionately. Nevertheless, it is worth noting that students' performance was consistent during the five-semester time period when the original assignment policies were in place.

Paired T-test for Fall 2018 and Spring 2019 Semesters

Beginning in fall 2018, the author changed the assignment policies; the 96 students in this part of the study had less time and fewer attempts to complete the assignments, but they had access to hints and the chance to check their answers one time before submitting their assignments for grading. Essentially, these policies remained the same in the spring of 2019, although the number of attempts allowed was reduced from two to one. A paired t-test analysis compared the scores from one semester to the next. The difference in the overall average assignment scores between the two semesters was not significant, and no semester consistently had higher individual assignment scores than the other. Therefore, students' performance was stable for the entire academic year.

Paired T-test for Pre- and Post-Policy Changes

To summarize, there were no significant differences in the overall mean assignment scores from spring 2016 to spring 2018 when the original assignment policies were in effect. Furthermore, there was no significant difference between the overall scores in the two semesters after the policies changed. By averaging the nine quantitative assignment scores from spring 2016 to spring 2018 semesters to form the first group and then averaging the same assignment scores for fall 2018 and spring 2019 to create the second group, a paired t-test analysis tested for a difference in the means of the assignments before and after the policy changes.

The analysis revealed that the difference in the mean assignment scores before the policy changes was significantly different from the scores after the policy changes. Scores after those changes were nearly 15% higher than before the policy adjustments. Moreover, the average score for all nine quantitative assignments was higher after altering the assignment policies. These results indicate that students' performance benefited from the access to the hints and the opportunity to check their answers one time but not negatively affected by having less time and fewer attempts to complete their assignments.

Future Quantitative Assignment Policies

While preparing to teach the operations management course online, the instructor created tutorials that simulated the methods used to solve the quantitative assignments in her face-to-face classes. What the instructor failed to do was to provide an in-class equivalent for students to get timely answers to their questions when they had difficulty solving the problems. Upon reflection, the author was not providing students with the timely feedback they needed. Their fellow students or instructor could not be on-call 24/7. Students needed new ways to get on-call answers to their questions. The assignment policy changes begun in fall 2018 are a step in the right direction. By allowing students access to problem-solving hints and the ability to check their answers for each problem, students did not have to rely on other students' or the instructor's availability.

When the author read the course evaluations in spring 2019, no one complained about having only one attempt to complete the quantitative assignments, but several students lobbied for more than one opportunity to check their answers. One student wrote, "How can I learn anything if I can only check my answers one time?" That made the author realize that students can benefit from knowing whether their answers are correct and using that information to redirect them to the tutorial for help. By providing students with a second opportunity to check their answers, they are more likely to try learning how to solve the problem rather than getting angry and giving up on the assignment.

Another frequent comment from the spring 2019 course evaluations was about the due date for the quantitative assignments. Students wrote that they did not have enough time to study for the chapter exam, due on Saturday, because the detailed solutions for the quantitative assignments were not available until after the quantitative assignment's Friday due date. Many students argued they required more time to learn from their mistakes on the quantitative assignment before taking the chapter exam. If the instructor wants to discourage procrastination and help students manage their time well, the due dates for assignments need to support those intentions. Looking back on the original policy of all assignments opening at midnight on Monday and closing at 11:59 p.m. on Sunday, it is evident that students did not benefit from that freedom and flexibility. Moving the quantitative assignments' due date to Friday was a step in the right direction, but students need more time between the quantitative assignment and chapter exam due dates.

Going forward, the instructor will revise her policies to encourage students' time management and provide them with timely feedback to improve their success. To accomplish these goals, she intends to open the assignments at midnight on Saturday and have the quantitative assignments due on Wednesday by 6:00 p.m. and the chapter exam due by Friday at 6:00 p.m. The policies for the quantitative assignments will allow students only one attempt to complete the assignment and still have access to the publisher's hints but provide two opportunities to check the correctness of their answers before submitting their assignment. The revised due date intervals should encourage students to begin their assignments earlier, and have more time to ask the instructor questions about the quantitative assignments and study for the chapter exam.

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APPENDIX A

Each semester, operations management students were assigned nine quantitative assignments. Below is the list of those assignment topics and details about the specific problem types included in each topic.

1. Break-Even Analysis
   - Process Choice
   - Equipment Choice
2. Statistical Quality Control
   - Process Capability
   - Mean and Range Charts
   - p-Charts
   - c-Charts
3. Project Management
   - Critical Path Method
   - Critical Path Method with Three Time Estimates
4. Aggregate Planning Techniques
   - Constant Workforce
   - Variable Workforce
   - Variable Inventory Levels
   - Stockouts, Overtime, and Subcontracting
5. Independent Demand Inventory
   - Single-Period Model
   - Fixed-Order Quantity Model
   - Reorder Point Models
   - Fixed-Time Period Model with Safety Stock
   - Price-Break Models
   - ABC Classification
6. Dependent Demand Inventory
   - Material Requirements Planning
   - Lot Sizing—Lot-for-Lot, Least Total Cost, and Least Unit Cost
7. Logistics and Transportation
   - Factor-Rating Systems
   - Transportation Method of Linear Programming
   - Centroid Method
8. Line Balancing
   - Longest Task Time
   - Greatest Number of Following Tasks
9. Forecasting
   - Simple Moving Average
   - Weighted Moving Average
   - Exponential Smoothing
   - Linear Regression Analysis
   - Decomposition of a Time Series
   - Forecast Errors—MAD, MAPE, and Tracking Signal
   - Multiple Regression Analysis

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