The Value of Multiple Choice Questions in Evaluating Operations Management Learning Through Online Homework Versus In-Class Performance

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ABSTRACT

While previous studies evaluated differences in the online and face-to-face environment for graduate and undergraduate students' performance on quantitative concepts, this study analyzes the results for qualitative concepts tested at the lowest levels of Bloom's taxonomy, knowledge and comprehension, through multiple choice questions. For undergraduate and graduate students significant differences between student performance on computer-managed and follow-up in-class factual multiple choice questions exists. Virtually no correlation between the computer-managed homework and in-class testing performance exists for the qualitative questions. Results highlight the need for instructors to be aware of the classroom activities and the learning level they are seeking to test online and in-class, as well as implications for computer-managed homework designers and instructors.

Keywords: Online Education, Multiple Choice

INTRODUCTION

Previous research evaluated the performance of undergraduates and graduates on online homework versus in-class performance with a particular emphasis on the quantitative question format (Fish, 2013, 2014a, 2014b, 2015). However, the value of qualitative questions to online learning in the business classroom remains relatively unexplored. This study seeks to begin that conversation by evaluating student performance at the lowest levels of Bloom's taxonomy (the knowledge and comprehension levels). The purpose of this study is to analyze whether student's who appear to demonstrate knowledge and comprehension learning online (prior to in-class testing) can then recall that information on in-class testing.

LITERATURE REVIEW

In today's educational environment, there is a transition towards inclusion of more online technology into the classroom. Administrators argue that online learning performance is the same or superior to those in the traditional face-to-face (FTF) classroom (Allen & Seaman, 2013). Others argue that online education does not replicate the learning that occurs in the traditional FTF classroom due to intrinsic differences (Bejerano, 2008). Falsely, instructors assume that whenever information technology is implemented into the classroom environment, it contributes to student learning (Peng, 2009). Previous studies highlight the need for instructors to evaluate online activities to verify their relevance to student learning (e.g. Braunscheidel, Fish & Shambu, 2013; Fish, 2012, 2013, 2014a, 2014b, 2015; Santos, Hu & Jordan, 2014). Online activities may include computerized homework, quizzes, exams, discussion board contributions, case study evaluations, and individual and group projects.

Research into the debate regarding student homework as contributing to student ability, knowledge and material retention reveals mixed results. Some studies find positive relationships (Eskew & Faley, 1988; Fisher & Holme, 2000), while others found no relationship (Peters, Kethley & Bullington, 2002). Similarly, research into the value of online homework is also mixed (Smolira, 2008) with some studies demonstrating positive results (Arasasingham, Martorell & McIntire, 2011; Arasasingham, Taagepera, Potter, Martorell & Lonjers, 2005; Biktimirov & Klassen, 2008), and others demonstrating negative or insignificant results (Anstine & Skidmore, 2005; Bonham, Beichner, & Deardorff, 2001; Bonham, Deardorff & Beichner, 2003; Cole & Todd, 2003; Daymont & Blau, 2008; Fish, 2013; Horspool & Lange, 2012; Topper, 2007). Some studies show weak correlations between online homework and student performance on examinations (Chamala, Ciochina, Grossman, Finkel, Kannan & Ramachandran, 2006; Fisher & Holme, 2000).

Many subject areas have started to research the relationship between web-based homework and student performance. For an undergraduate business statistics course, an insignificant relationship between web-based homework and overall performance exists (Palocsay & Stevens, 2008). Similarly, in a math course, student

performance was significantly better when using computer-generated math homework versus traditional methods (Kodippili & Senarantne, 2008). In a comparative study between four instructors using the same online homework system, only one instructor noted student improvement in exam performance through online homework (Dufresne, Mestre, Hart & Rath, 2002). Some instructors feel that students increase their homework efforts to merely accomplish it and not necessarily learn the material (Peng, 2009). There is still a lack of consensus regarding the effectiveness of online homework, which highlights the need for further investigation (Arasasingham, Martorell & McIntire, 2001).

Previous research evaluated the performance on computer-managed homework and subsequent in-class testing for different formats for undergraduates (Fish, 2014a) and graduates (Fish, 2014b). Graduate and undergraduate students demonstrated a moderate level of learning between computer-scaffolded to in-class scaffolded learning, but open-ended and partial open-ended learning were weaker (Fish, 2013, 2015). However, differences exist between graduate and undergraduate performance in online homework performance as graduate students perform better than undergraduates (Fish, 2012), and academic maturity is a significant factor as upper level students perform significantly better than freshmen (Urtel, 2009). These studies focused on testing student performance on quantitative – not qualitative – questions in operations management. For quantitative questioning, one value to online quantitative homework that is often sighted is the random number assignment, which forces each student to use different numbers to analyze. This randomization does not exist with qualitative questions, other than to randomize the order of the questions or alternatives between students.

While students may have a preferred method to study for a particular course, the learning outcomes, assessments, teaching method for the course and learning goals can impact how the students study (Hadwin, Winne, Stockley, Nesbit & Woszczyna, 2001). A well-known framework for classifying what instructors expect students to learn as a result of instruction is Bloom's taxonomy, which represents a continuum of increasing cognitive complexity (Krathwohl, 2002). Many instructors feel that qualitative multiple choice questions (MCQ) tend to be appropriate at the lower levels of Bloom's taxonomy – the knowledge or comprehension levels. At the knowledge level, student recall information, while at the comprehension level, students explain information. Qualitative testing through MCQ at the lowest levels of Bloom's taxonomy, knowledge and comprehension, is the focus of this research.

With respect to previous studies on MCQ, an early operations management study found no relationship between required homework and performance on a multiple choice exam for undergraduates (Peters, Kethley & Bullington, 2002). The study did not indicate whether the MCQ were qualitative or quantitative in nature. However, another preliminary study showed a mild correlation in support of learning through MCQ for qualitative material at the knowledge level for undergraduate students (Fish, 2014a). In an introduction to psychology course, students performed significantly better on factual MCQ with older students performing better than younger students on both factual and applied MCQ (Yonker, 2011). The psychology study also showed that there was no relationship between a reported deep study approach and MCQ achievement, and that a reported surface strategy had a detrimental impact on MCQ exam scores (Yonker, 2011). A surface strategy approach emphasizes the reproduction of what is taught to meet the minimum external assessment requirements, while a deeper approach focuses on learning for learning's sake and encourages an abstract level of conceptualization (Yonker, 2011).

While many people assume that MCQ address lower levels of Bloom's taxonomy, MCQ can be higher–ordered conceptual or applied questions (Yonker, 2011). A study on introduction to finance students and using MCQ for assessment revealed that student performance at the lowest level, knowledge, was actually worse than on higher level MCQ (Santos, Hu & Jordan, 2014). They attributed the students' poor performance on the knowledge-based MCQ to the extensive focus in the classroom on computations, the potential skimming by students of textbook material rather than careful reading, and a focus on problem-solving using calculators (Santos, Hu & Jordan, 2014). In a graduate school of business in Australia, the use of assertion-reason questions, a sophisticated form of MCQ, revealed that this type of MCQ corresponds to student performance in essays, which are regarded as a measure of deeper thinking (Williams, 2006). However, the study also highlighted the critical importance of question wording in student performance, particularly for students completing the MCQ not in their native tongue, as well as the time a student takes to process the complex prose of the MCQ as contributing factors (Williams, 2006).

Ideally, the instructor should use the appropriate question for the learning level that matches the learning goals. A common goal of education is to educate the individual for the long-term and not just in the short-term. *What is the relationship between using MCQ to evaluate short- and long-term learning?* In a computer-based study of medical education, computer-based teaching revealed that teaching strategies that improve short-term learning do not

necessarily improve long-term knowledge retention (Mounsey & Reid, 2012). Older students tend to use a surface learning strategy less than a deep strategy (Watkins, 1982).

Through their education, students learn factual information, such as a definition for a term. We refer to this as 'factual information', which corresponds to Bloom's knowledge or comprehension level. In a continuation of this vein of research, this study seeks to evaluate the relationship between factual homework MCQ and factual in-class MCQ performance on qualitative concepts. Specifically, this study seeks to explore the following hypotheses:

H1: General Learning: There is no significant difference between student's performance on online qualitative, factual homework MCQ items versus performance on in-class qualitative, factual MCQ items.

H2: 'Short-term' Learning: There is no significant difference between student's performance for online qualitative, factual MCQ versus performance on in-class qualitative, factual MCQ items in the 'short-term' (days).

H3: 'Longer-term' Learning: There is no significant difference between student's performance for online qualitative, factual MCQ versus performance on in-class qualitative, factual MCQ items in the 'long-term' (weeks or more).

METHOD

Over the spring semester, one graduate section (26 students) and two undergraduate sections (63 students) of operations management at an AACSB-accredited university in the northeast (which focuses on teaching) used a computer-managed homework system as part of their coursework. The graduate class average age was roughly 26 years old, with 11 females and 15 males. The undergraduate classes included 17 females, 46 males and averaged 20 years old. (Since the intent of this research is to evaluate student performance between computer-managed homework and in-class performance, and not to evaluate the specific computer-managed homework system, the specific package and textbook will not be noted other than to note that they are very popular in the operations management arena.) The same instructor taught the three sections. The undergraduates and graduate students used the same online homework program, but they used different textbooks and different MCQ.

For the full-time undergraduates, homework corresponded to 5% of their overall grade, and was due on the evening prior to the corresponding in-class quiz. The instructor included quantitative problems corresponding to the textbook and in-class problems as well as instructor developed MCQ on qualitative concepts. The qualitative, factual MCQ were similar to the textbook questions and would be classified as 'easy to medium' difficulty. Students could use their notes and the textbook to complete the homework. An example of an undergraduate MCQ used is:

Which of the following is NOT an operations management issue during the growth stage of the product life cycle? (Note: "Reduce capacity" is the correct response.)
Shift towards product focus
Forecasting critical
Enhance distribution
Reduce capacity

Quizzes were worth 23% of the final grade, and the best 7 of 9 quizzes counted. Quizzes were worth 10 points each and included MCQ, and either short answer questions, quantitative problems or interpretation questions. Three non-cumulative exams were each worth 24% of the final grade. The format of the exams included multiple choice, short answer questions, interpretation questions and quantitative problems. The instructor included 1 multiple choice question from the proceeding homework on the corresponding quiz and a different, but previously administered homework multiple choice question for each of the prior homework was included on the exam. While not tracked, it appeared that many students procrastinated and completed the homework the evening before the corresponding quiz, and not earlier in the week. Since the online homework was attempted within days of taking the quiz, student performance was regarded as 'short-term learning' for this relationship. (In many cases, students completed the homework within 24 hours of taking the quiz.) However, with respect to the relationship between the online homework and the exam, the homework was available over weeks earlier (24 days). However, for relationship between the online homework and the exam was at least a week as the homework was due at least a week prior to the corresponding exam. Therefore, the homework to exam performance can be viewed as 'longer-term' learning. For the analysis, the instructor gathered the corresponding multiple choice scores from the online homework,

quizzes and exams over the semester. Three students dropped the course just prior to the third exam. For the analysis, these students were included in the overall and quiz analysis, but not the exam analysis.

The graduate students were part-time evening students at the university. Nine homework assignments were given and corresponded to 5% of the students' final grade. (Note one quiz which was totally qualitative did not have a corresponding homework assignment.) Similar to undergraduate students, homework was due the evening prior to the corresponding quiz. The online homework included quantitative problems and instructor generated qualitative, factual MCQ's. The qualitative, factual MCQ's corresponded to the textbook test bank and difficulty of 'easy to medium'. The following is an example of the difficulty of the MCQ:

Which of the following conditions is generally associated with a job process? (Note 'high resource flexibility' is the correct response.)
High product or service volume.
Resources are allocated to specific products.
Relatively standardized products.
High resource flexibility.

Ten quizzes, worth 31% were administered over the course of the semester, with the best 8 counting toward a student's final average. Each quiz, worth 15 points, included MCQ, short answer, and either a quantitative or an interpretation problem. A midterm and a final exam were administered in-class, and each exam corresponded to 32% of the student's final average. Both exams included MCQ, short answer questions, interpretation questions and quantitative problems. Similar to the undergraduate class, the instructor tracked the corresponding multiple choice scores from the online homework, quizzes and exams over the semester. While 26 students completed the course through the last week of classes, 2 students participated in the entire semester, but chose to withdraw prior to the final exam. Their performance was included in the quiz analysis, but not the exam analysis. For the analysis, the instructor gathered the corresponding multiple choice scores from the online homework, quizzes and exams over the semester.

ANALYSIS

Given the nature of the methodology used, statistically the design included a pre-testing performance (the online homework) and a testing (quiz or exam) as a Student-paired t-test. With respect to MCQ, the answer is either correct or it is incorrect, and therefore, a one-tail test is more appropriate than a two-tail test. All of the undergraduate students completed the online homework, while at the graduate level, two students chose not to do the online homework. Since there were only two students in this 'group', statistical analysis is not possible.

Undergraduate Students

In general, undergraduate students performed well on homework MCQ (μ= 98.18), but did not perform as well on in-class MCQ on quizzes (μ = 86.99), the exams (μ = 73.95) or overall in-class testing (μ = 80.40) as shown in Table 1.

Table 1: Undergraduate Student Average and Standard Deviation for MCQ

	Online	In-class Testing		
	Homework	Quizzes	Exams	Overall (Quizzes & Exams)
Average	98.18	86.99	73.95	80.40
Standard Deviation	0.13	0.34	0.44	0.40

As summarized in Table 2, student t-test comparisons reveal that undergraduate student performance on homework versus in-class testing for the multiple choice was significantly different (p=.000). (By in-class testing, we refer to the in-class student performance on both quizzes and exams.) Since students' performance on the online homework for qualitative MCQ's was very consistent and very good (μ =98.18, σ = .13), comparison between the students who did poorly online versus those who did well could not be performed. As expected, a comparison for 'shorter-term' (p=.000) and 'longer-term' (p=.000) learning also demonstrates a significant difference in performance between online and in-class performance. The correlation between the homework and the overall in-class testing (r = .07), between online homework and quizzes (r = .05), and online homework and exams (r =.08) were all very weak.

Table 2. Undergraduate Student t-test Results and Correlations

Online Homework vs.	Quizzes	Exams	Overall (Quizzes & Exams)
t-tests	.000*	.000*	.000*
Correlation	.05	.08	.07

* = Significant at p≤ .05

Graduate Students

In general, graduate students performed well on homework MCQ (μ= 98.84), but did not perform as well on in-class MCQ on quizzes (μ = 86.06), the midterm exam (μ = 85.42) or the final exam (μ = 79.55) as shown in Table 3.

Table 3: Graduate Student Average and Standard Deviation for MCQ

	Online	In-class Testing		
	Homework	Quizzes	Exams	Overall(Quizzes & Exams)
Average	98.84	86.06	82.48	84.24
Standard Deviation	0.11	0.35	0.38	.36

As shown in Table 4, results of the Student t-test comparison for the MCQ, reveal that graduate students performance on homework and in-class for multiple choice was significantly different (p=.000) overall, between homework and quiz performance (p=.000), and between homework and exam performance (p=.000). The overall correlation between the online homework and in-class testing was insignificant (r = .03). The correlation between online homework and in-class exam questions was very weak as well (r = .09). Surprisingly, the correlation between online homework and in-class quiz questions was actually negative (r = -.04)!

Table 4. Graduate Student t-test Results and Correlations

Online Homework vs.	Quizzes	Exams	Overall (Quizzes & Exams)
t-tests	.000*	.000*	.000*
Correlation	-.04	.09	.03

* = Significant at p≤ .05

DISCUSSION

Undergraduate and graduate students performed significantly better on MCQ for their homework than for follow-up in-class testing regardless of whether the testing was shorter-term (quizzes) or longer-term (exams). All of the hypotheses are not confirmed as students who completed online qualitative MCQ did not perform equally on follow-up in-class testing. They did not perform well when the in-class testing occurred within a shorter term (quizzes) or over a longer term (exams). Obviously, in completing the online homework, students had access to other resources, such as notes and textbooks. However, they may or may not have used these resources to complete the qualitative question. In class, students had to rely on whether they learned the material or not to select the correct answer.

The relationship between online multiple choice qualitative questions and in-class testing was very weak. When completing online questions, students have access to several resources. By completing the online question, as demonstrated here, the student does not necessarily retain the material that was tested. Also, in-class instructors should be aware that students may purchase test banks to courses. (Ideally, in an online course if the MCQ is part of testing, a proctoring site is recommended.) These weak correlations and low t-test scores appear to indicate that the students used surface strategies to learn the material – and not deeper learning strategies. These results correspond to the finance study (Santos, Hu & Jordan, 2014) and may highlight the operations management instructors focus on calculations and students 'skimming' instead of reading the material thoroughly. These results appear to demonstrate that due to the lower order skills necessary to complete the factual MCQ, students did not necessarily learn the concepts. These results highlight that while students perform well on online homework for factual, qualitative MCQ's, in subsequent testing, they do not appear to remember the 'basic' information. Perhaps in completing the homework, students merely look up the information, and do not transfer the information to long-term memory.

Qualitative MCQ are appropriate to test at the knowledge and comprehension levels of Bloom's taxonomy. However, these results show that long-term learning of qualitative concepts was not demonstrated. *How long does a student retain information tested through qualitative MCQ online or in-class?* These results demonstrate that both graduate and undergraduate students did not retain the information very long as both the 'shorter-term' and 'longer-term' correlations were insignificant or extremely weak. Basically there was no relationship between how a student did on the online questions and the in-class questions – even though the qualitative questions were exactly the same! This is similar to the medical study where short-term learning strategies were not related to long-term knowledge retention (Mounsey & Reid, 2012). However, since the graduates and undergraduates did not learn the material through factual MCQ, the results here contrast the psychology study where students performed well on factual MCQ which require shallow cognitive processing (Yonker, 2011). Since the undergraduate and graduate students used different questions, the graduate and undergraduate results cannot be compared other than to note that both groups did not demonstrate learning the material.

As for 'shorter term' and 'longer term', since specific time frames between when students completed the online MCQ and when they completed the in-class question were not tracked, more detailed tracking may assist in differentiating short-term and long-term learning. A future study should evaluate student performance when the timeframe is tracked between the online and the in-class question.

CONCLUSION

Regardless of the timeframe between online performance and in-class testing, the results highlight that students do not perform at the same level for qualitative, factual information MCQ between online assignments and in-class testing. It appears that students do not learn the material when they complete online questions that test at the lowest levels of Bloom's taxonomy (the knowledge and comprehension levels). In keeping with Bloom's taxonomy, instructors need to be mindful of the MCQ analysis level as well as what they are presenting in the classroom. Using online, factual MCQ's appears to have little value to student learning of basic information at the knowledge and comprehension levels. Further analysis is needed to test whether students' performance is acceptable for MCQ's that test at the higher levels of Bloom's taxonomy (the application, analysis, synthesis and evaluation levels). Future studies need to continue to analyze the relationship between online assignments and testing and traditional face-to-face student performance.

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