Online Supplemental Tutorial Videos for a Quantitative Management Science Course

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ABSTRACT

This paper describes the implementation and assessment of supplementary online video tutorials in a management science course. The videos were a mix of existing videos curated from the web and new videos created by the instructors of the course. Students were encouraged to use the resources with grade incentives. Students who used more of the resources performed significantly better in the course. In addition, most of the students perceived the videos as helpful.

Keywords: Tutorial videos, management science, supplements, instructional podcasts

INTRODUCTION

Availability of free online resources for learning has increased dramatically over the past few years. Khan Academy offers thousands of high quality free tutorial videos on mathematics, science and other subjects. YouTube offers countless tutorial videos in every subject imaginable. Numerous other sources for educational videos can be found in websites such as Refseek (2013) and Getting Smart (Schneider, 2013). In addition, a number of massive open online course (MOOC) platforms such as Coursera, Udacity, and edX offer free college-level courses with video lectures. Use of online videos and podcasts have become increasingly popular in traditional university courses as well, sometimes replacing face-to-face lectures (for example, in the flipped classroom model) and sometimes supplementing them. Sometimes instructors author their own videos; sometimes they tap into the trove of material already online.

In fact, students often seek out these online resources on their own. Paradoxically, the more resources are available the more difficult it is for students to find the particular resources that will be most helpful for their own course. Thus, it is becoming important for instructors to guide their students' search for supplementary online material. A potential beneficial use for such tutorials is to assist the underprepared students in a course that includes students with a wide range of abilities. This paper describes such a remediation effort in an introductory management science course. Both videos authored by the instructors and videos curated from the web were used to supplement the course which met in traditional classroom format. The main goal of the supplementary video tutorials was to improve learning in a course that students typically find challenging, and especially to improve learning of the underprepared students.

In the next section, we describe studies that theorize how supplemental videos could be helpful in quantitative courses, and those that describe implementation of such videos.

LITERATURE REVIEW

Learning Quantitative Disciplines

In teaching quantitative courses in a university setting, professors have often reported finding students entering their classes deficient in the math skills that are needed for success in the course (Baharun & Porter, 2012; Johnson & Kuennen, 2006; Kay & Kletskin, 2012; Xu, Meyer, & Morgan, 2009). Johnson and Kuennen (2006) note that prior math skills are important for success in a business statistics course; a follow-up study by Lunsford and Poplin (2011) reinforced this finding.

Hence, the classes in mathematical disciplines could benefit from a tool that would help create a more uniform set of prior knowledge, even as a review, preferably without detracting

from class time for the new material. Johnson & Kuennen (2006) suggest using reviews of background math as a supplement to courses in statistics in order to improve success. Yates (2005) suggests building in a course routine that includes remediation, review, and individualizing instruction to each student's needs. Complex material should be broken down into small parts so students can learn incrementally (Sweller & Chandler, 1994Mayer, Mathias, & Wetzell, 2002; Ayres 2006).

Benefits of Supplemental Video Podcasts

Video podcasts are a potential tool for addressing some of the difficulties inherent in teaching quantitative disciplines. Video podcasts have been used in several ways: to deliver lectures in an online class, to supplement the class by adding material that is not included in lectures, or as a creative tool for students to present their own work (McGarr, 2009). Among these, McGarr (2009) advocates supplemental video use as the most beneficial to learning. Such supplements may reinforce, provide extra examples, and add visual perspective to fields that are awkward to present without videos.

Videos are thought to be especially useful in situations requiring instructors to demonstrate methods and solve exercises (Gattis, 2008; Holden & Westfall, 2006). Sargent, Borthick, and Lederberg (2011) suggest that weak students could benefit from supplements enabling them to master small pieces of learning. Videos increase contact time for students when used to supplement class time (Chickering & Gamson, 1987). Furthermore, repetition can be used to deepen understanding and achieve high levels of academic performance (Cooper, 2004), and videos provide opportunities for students to view content as many times as necessary. Stephenson, Brown, & Griffin (2008) found that videos of PowerPoint slides with audio annotations are associated with better than average performance on factual recall exam

questions. One explanation cited by these studies is that students can listen to or watch podcasts multiple times, while lectures are only available once.

Studies with Supplemental Videos

Instructor-authored videos have been used in a variety of classes including management science/operations research (Hardin & Ellington, 2005; Leon, Seal, & Przasnyski, 2007; Nurre & Sharkey, 2013), accounting (Rich, 2012; Sargent, Borthick, & Lederberg, 2011), pre-calculus (Kay & Kletskin, 2012), chemistry (He, Swenson, & Lents, 2012), engineering (Goeser, Flett, Kriske, & Panter, 2012), and architecture (Comiskey & McCartan, 2011). Overall, student response to video availability was positive in all of these studies. However, support for demonstration of improvement in learning outcomes was weak; and not all authors measured learning outcomes. The results from these studies are summarized here.

Hardin and Ellington (2005) created video tutorials demonstrating Palisade DecisionTools suite, a set of add-ins for Excel, in an undergraduate Mathematical Modeling course. Pre-test and post-test demonstrated significant improvement after viewing the videos. Leon, Seal, and Przasnyski (2007) developed interactive screen capture modules for demonstration and practice of Excel modeling tools such as Regression and Data Table for an MBA Financial Modeling course and an undergraduate Production Operations Analysis course. Nurre and Sharkey (2013) developed video tutorials to demonstrate additional examples for various topics covered in an operations research course. Sargent, Borthick, and Lederberg (2011) used 27 three-minute videos for students in a principles of accounting course. Video use was significantly correlated with better pass rates and lower drop rates and small but significant increases in exam scores; comparing two year periods before and after adding the videos to the course, course grades were higher. In another accounting course reported in Rich (2012), a series of ten instructor-authored

exercise-based supplemental video podcasts improved student performance on the midterm compared to an earlier semester without the videos, although the difference was not statistically significant.

Kay and Kletskin (2012) created a series of 59 video podcasts covering five pre-calculus areas: operations with functions, solving equations, linear functions, exponential and logarithmic functions, and trigonometric functions. Each video had a problem solved by a teacher along with a corresponding problem to be solved by the student. Comiskey and McCartan (2011) created supplemental video tutorials for learning to use a Computer Aided Design (CAD) package in an undergraduate program in Architectural Technology and Management. Goeser, Flett, Kriske, and Panter (2012) created video tutorials as a supplement in a Computing for Engineers course to help students retain concepts and apply them to problem solving.

In addition to videos created by the instructors, instructors can integrate videos that are available online. Gönül and Solano (2013) required Khan Academy assignments in business statistics and operations management courses. The effect of participation in Khan Academy assignments on exam scores was significant and positive, but not significant after accounting for student-specific characteristics.

Limitations

A limitation of many of these studies is that it is difficult to isolate the effect of the tutorial videos on learning. It may be that much of the benefit derived from tutorial videos is from the extra time on task that any supplement to the course would provide. Students' repetition, drill, and practice may have been accomplished similarly without online delivery; technology then just provides an efficient delivery tool (Leidner & Jarvenpaa, 1995). Also, it is possible that those

students who opt to use the video tutorials are the more motivated students who generally tend to do better.

In these studies, effectiveness of the tutorial videos was typically measured by a survey of student perception and comparison of student performance between the term when the videos were offered and a prior term when the videos were not offered. In this paper, we measure the relationship between the use of the tutorials and performance for the same cohort of students. In addition, both existing online videos and new videos were integrated to provide remediation of basic materials and reinforcement of concepts covered in the course.

THE TUTORIAL VIDEOS

The tutorial videos in this paper were implemented in the fall 2013 and spring 2014 semesters at a private metropolitan university with a student body characterized by a wide range of ability. The authors regularly teach a junior-level introductory management science course required of all undergraduate students in the business school. Students are the juniors and seniors who have taken finite mathematics (a freshman level course covering introduction to probability concepts, linear programming concepts, and basic financial mathematics) and a statistics course as pre-requisites. Although these students have taken two college-level math courses, many of them have difficulty with seemingly simple algebraic concepts such as inequalities and interpreting simple linear expressions.

As part of the business school's continuous improvement effort, a set of tutorial modules was developed to help the students who are underprepared. An extensive search of online videos provided a list of relevant videos. For the topics for which appropriate videos could not be found, the instructors created a set of videos. The videos were in two categories: those

reviewing basic math and Excel skills and those that provided alternative examples to some of the topics covered in the course.

Review Tutorials

Johnson and Kuennen (2006) found that an important student characteristic associated with success in an introductory business statistics class was the student's score on a test of basic mathematical concepts. Hence, the first recommendation from this paper was to include reviews of relevant math concepts before introducing the statistics concepts, possibly with online math reviews to be completed outside of class. The same recommendation should hold for the management science course.

Hence, in the management science course, a review module was provided consisting of nine short videos curated from the web. The videos are listed in Table 1. The first three videos out of the nine videos were from Khan Academy. The total length was approximately an hour.

INSERT TABLE 1 HERE

To encourage the underprepared students to view these videos, students were given a pre-review quiz and a post-review quiz covering the materials in the videos. The pre-review quiz, given on the first day of the class, served as a diagnostic tool and did not count toward the course grade. The quiz was graded immediately so students were able to see which questions they missed. They were then given a post-review quiz a week later under the same conditions (which did count toward their grade) after having had a chance to view the tutorials covering the questions they missed. The post-review quiz was different from the pre-review quiz, but covered the same topics at a slightly more challenging level. While they were not required to view the videos, the students were motivated to view many of them to prepare for the post-review quiz.

According to students' self-reporting, the average number of videos viewed by students was 4.6 out of 9 with 76% of students viewing at least one video and 24% reporting that they viewed all nine videos.

Topical Tutorials

In addition to the review videos, students were provided videos with alternative examples for the course topics they tend to find challenging. These topics were conditional probability, decision analysis, and linear programming formulation. A set of five optional tutorial modules were provided as shown in Table 2. Each module had one or two videos with an accompanying online quiz.

INSERT TABLE 2 HERE

The two conditional probability videos were found on YouTube (http://youtu.be/UE8u7JZqyl4, http://youtu.be/KIDplYpM4tM). The others were created by the authors. Decision Analysis 1 covered an introductory example with one-step decision making and Decision Analysis 2 covered two-step decision making with a decision tree. Linear Programming (LP) Formulation 1 covered a simple example with two products and three resource constraints and LP Formulation 2 illustrated a translation approach with the bookstore example from Stevens and Palocsay (2004). As a sample, Decision Analysis 2: Decision Tree 1 video can be seen at: http://youtu.be/ez4yTfUQXG8. The quiz included in each module served to reinforce the concepts covered in the videos and to verify that students viewed the videos.

Extra credit of one percentage point was assigned for each module completed with a minimum quiz grade of 80%. Each module deadline coincided with the timing of the topic.

ASSESSMENT

The effect of the tutorials was evaluated in six sections of the management science course taught by the authors in fall 2013 and spring 2014. The total number of students enrolled in these sections was 169. In addition to tracking the student performance related to the video tutorials, we surveyed the students on the perceived helpfulness of each video.

Review Tutorials

A total of 144 out of 169 students took both the pre-quiz and the post-quiz (some students were absent one of the quiz days). The comparison of performance is summarized in Table 3. The mean score increased from 59.4 on the pre-quiz to 71.4 on the post-quiz. The paired-sample t-test indicated that the difference was statistically significant with $p = .000$.

INSERT TABLE 3 HERE

Table 4 shows the correlations among the pre-quiz score, number of review videos viewed, score on the post-quiz, and the improvement from the pre-quiz to the post quiz. Surprisingly, there was no significant relationship between the number of review videos viewed and the performance on the post-quiz (or improvement from pre- to post-quiz). Both relationships had correlations close to zero ($r = -.042$, $p = .734$ for post-quiz and $r = -.115$, $p = .349$ for improvement).

INSERT TABLE 4 HERE

The lack of relationship between review videos viewed and performance on the post-quiz could be due to inaccurate or inflated reporting, as the survey was not anonymous. Another

possible reason is that some students may have relied more on other methods of studying, perhaps reviewing the pre-quiz and other resources. Additionally, since the pre-quiz did not count toward the grade and the post-quiz did, students may have tried harder on the post-quiz. The pre-quiz was given without warning while the post-quiz was announced ahead of time and students knew what kind of questions to expect.

Topical Tutorials

As for the effect of the topical tutorials on class performance, the number of tutorials students completed was compared to the performance on the related assignments and the midterm exam. The midterm exam covered decision analysis, linear programming formulation, and forecasting. The five topical tutorials covered conditional probability (in preparation for decision analysis), decision analysis, and linear programming. The optional topical tutorials were in addition to required weekly assignments. For those who wanted to complete the tutorials for extra credit, they were advised to complete the tutorials before attempting the related assignments.

The sample here included 117 students from two sections in fall 2013 and two sections in spring 2014. Eighty-two (70%) completed at least one out of the five tutorials. Table 6 shows the mean percentage points on the related assignments and the midterm exams based on number of tutorials completed. The instructor attempted to encourage weaker students to complete the tutorials by stating that students who received a lower score on the pre-quiz should do them. But there was no significant relationship between the number of tutorials completed and the score on the pre-quiz ($\chi^2(5) = 6.26$, $p = .282$).

In addition, as an important goal was to increase the proportion of students who achieved "acceptable" performance, Table 5 shows the percent of students who scored 80 (grade of "B")

or higher out of 100 on the midterm exam. The mean scores of assignments and midterms are also plotted in Figure 1. While the mean scores do not always increase with each additional tutorial, the general trend is clearly upward. One-way ANOVA of assignment scores and midterm scores based on the number of tutorials indicated the tutorials had a significant effect on both measures of performance. The result of ANOVA was $F(5, 111) = 7.29$, $p = .000$ for assignment scores and $F(5, 111) = 4.42$, $p = .001$ for midterm scores. The percentage of 80-plus scores on midterm was also significantly related to the number of tutorials ($\chi^2(5) = 20.32$, $p = .001$). Comparing the students who completed two or fewer tutorials and those who completed three or more, 39% of the two-or-fewer group and 68% of the three-or-more group achieved 80-plus scores. The tutorials were significantly correlated to the assignment score ($r = .495$) and midterm score ($r = .390$) as well.

INSERT TABLE 5 HERE

INSERT FIGURE 1 HERE

While the number of tutorials was correlated with the midterm exam, the assignments had a much higher correlation with the midterm exam with $r = .700$ ($p = .000$). This is expected because the assignments were the main vehicle through which students practiced what they learned. The tutorials may have helped somewhat in completing the assignments, but they did not have as much effect on the midterm as the assignments did.

Survey of Student Perception

In spring 2014, two surveys were conducted to measure students' perception of tutorial effectiveness. Out of 103 enrolled students from four sections, 79 participated in the survey on review tutorials, and 65 participated in the survey on topical tutorials.

On both surveys, for each tutorial, students who viewed it were asked to choose among *definitely helpful, somewhat helpful, not helpful,* and *unsure*. Tables 6 and 7 summarize the results. The percent of students rating the video definitely/somewhat helpful ranged from 77% to 100% with an average of 89%.

INSERT TABLE 6 HERE

INSERT TABLE 7 HERE

The comments on the videos were generally positive, and it was clear students appreciated them. Several students who did not feel confident about their quantitative ability commented they felt helped by the videos. Below are samples of such student comments:

"Without these tutorials I would have been lost in the beginning of the semester."

"Tutorials were very helpful. I watched a lot of them because I was struggling in this class. A lot of this class has to do with math and is very technical, which is two of my weakest areas. After watching these videos I was able to do homework and understand the material better in general. I wish there were tutorials for everything."

"This is a tough class that I was nervous about taking, but the instructor has done a great job offering many resources to help the class learn."

Some of the better students felt some of the review videos were unnecessary: "The [review] videos were really helpful, but I found some to be unnecessary (especially the first 3 videos)." Some students admitted not utilizing the review videos: "Did not watch [review] videos. Used the pre-quiz to help with post-quiz."

DISCUSSION

The tutorials had a high participation rate and were overall effective in helping the students in course performance. The participation rates for both review and topical tutorials were high with 76% of students viewing at least one review tutorial and 70% of students completing at least one topical tutorial. As the original intent of the tutorial project was to help the weaker students, it would have been desirable to identify the remedial students and require them to complete the tutorials. However, this approach could be problematic since labeling some students as remedial and requiring them to do additional work can cause negative feelings among such students.

Hence, a more practical way was to make the tutorials available to all the students. It was hoped that the underperforming students would be motivated to use the tutorials with the post-quiz and the extra credit incentives. It should be mentioned there were also extra credit opportunities for solving more challenging problems on certain assignments to accommodate stronger students. In general, online tutorials can potentially be vehicles for differentiation. For example, students might be given extra credit for completing either tutorials for remediation or tutorials that cover advanced topics beyond those normally covered in class.

The average improvement from 59.4 on the pre-quiz to 71.4 on the post-quiz was statistically significant with $p = .000$. However, the improvement was not significantly related to the number of review videos students reported viewing. Some students who did not view the videos could have improved by preparing for the post-quiz by other means. Motivation of the graded post-quiz and familiarity with the type of questions could have helped improve performance as well.

The students who viewed more topical tutorials tended to do better on the midterm exam with a significantly higher percentage of frequent viewers (three or more tutorials) achieving a

grade of B or better on the midterm exam, 68% vs. 39%. The number of tutorials completed had significant, positive correlations with both the assignment scores and the midterm scores.

Students' perception of the tutorials was positive with an average of 89% of viewers rating them as helpful. Some students who have trouble with the course material will seek online tutorials, but it is difficult for students to find the video with the level, context and emphasis that fit the course. An instructor supplying the appropriate tutorials fills the need of such students. While curating or developing video tutorials is labor-intensive, we believe the benefit outweighs the costs. As online resources continue to proliferate, a part of instructors' responsibilities could be to guide the students to the appropriate resources.

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TABLES

Table 1: Review tutorials.

Video	Length (m:s)	Link
1. Order of Operations 1	4:35	http://youtu.be/gjrGd9TjjnY
2. Variables, Expressions, Equations	6:54	http://youtu.be/vDqOoI-4Z6M
3. Inequality Examples	8:01	http://youtu.be/xOxvyeSl0uA
4. Interest Word Problem	4:13	http://youtu.be/Pv-OZ3UJzMQ
5. Interpreting Slope and Intercept	4:07	http://youtu.be/w0PMKYVXXIA
6. Cumulative Probability	5:17	http://youtu.be/YX4XK1R_I8g
7. Excel for Beginners	12:37	http://youtu.be/L7dHA_8GzKw
8. The SUM and Average Functions	3:27	http://office.microsoft.com/en-us/excel-help/the-sum-and-average-functions-RZ101862712.aspx?CTT=1&section=4
9. More about Cell References and Formulas	9:50	http://office.microsoft.com/en-us/excel-help/more-about-cell-references-and-formulas-RZ101862712.aspx?CTT=1&section=5

Table 2: Topical tutorials.

Module	Video(s)	Length (m:s)
1. Conditional Probability	Conditional Probability - Introduction	10:30
	Conditional Probability: Part 2 (Independence)	7:41
2. Decision Analysis 1	Decision Theory Basics	12:33
3. Decision Analysis 2	Decision Tree 1	13:55
	Decision Tree 2	7:27
4. LP Formulation 1	Linear Programming Formulation	7:11
5. LP Formulation 2	LP Bookstore 1	6:43
	LP Bookstore 2	13:00

Table 3: Comparison of pre-quiz and post-quiz scores.

	Pre-quiz	Post-quiz	Improvement
Mean	59.4	71.4	12.0
SD	18.7	18.4	
N = 144			
p = .000			

Table 4: Correlations among pre-quiz score, number of review videos viewed, post-quiz score, and improvement (post-quiz score – pre-quiz score).

	Pre-quiz	Videos viewed	Post-quiz	Improvement
Pre-quiz		.066	.557**	-.508**
Videos viewed			-.042	-.115
Post-quiz				.432**
Improvement				

* $p < .05$, ** $p < .01$, $N = 68$

Table 5: Percentage points on the related assignments and the midterm based on the number of topical tutorials completed.

		Assignment		Midterm		Midterm >= 80	
Tutorials	*N*	Mean	*SD*	Mean	*SD*	Count	%
0	35	54.0	31.3	61.3	25.3	10	28.6%
1	16	71.2	19.2	73.8	19.3	6	37.5%
2	13	69.8	18.2	82.9	8.8	9	69.2%
3	10	74.1	20.3	71.8	18.2	4	40.0%
4	19	79.8	19.1	76.8	22.3	13	68.4%
5	24	89.3	17.9	84.8	18.9	19	79.2%
Overall	117	71.2	26.3	73.6	22.4	61	52.1%
Sig. *p*		0.000		0.001		0.001	
Correlation		0.495**		0.390**			

* $p < .05$, ** $p < .01$

Sig. *p* indicates *p* values of ANOVA for Assignment and Midterm and *p* value of chi-square for Midterm ≥ 80.

Table 6: Rating of review videos by students, *N* = 79.

Video	1. Order of operations	2. Variables, expressions, and equations	3. Inequality examples	4. Interest word problem	5. Interpreting slope and intercept	6. Cumulative probability	7. Excel for beginners	8. The SUM and average functions	9. More about cell references and formulas	Mean
% viewed	51%	48%	52%	51%	47%	54%	47%	46%	48%	49%
	% out of those who viewed									
Definitely helpful	45%	50%	49%	38%	46%	37%	51%	53%	58%	47%
Somewhat helpful	48%	37%	41%	43%	46%	40%	41%	47%	29%	41%
Not helpful	5%	5%	10%	18%	3%	12%	5%	0%	3%	7%
Unsure	3%	8%	0%	3%	5%	12%	3%	0%	11%	5%

Table 7: Rating of topical tutorials by students, N = 65.

Video	Cond. Prob.	Dec. Analysis 1	Dec. Analysis 2	LP Form. 1	LP Form. 2	Mean
% viewed	71%	72%	66%	69%	66%	69%
	% out of those who viewed					
Definitely helpful	57%	55%	60%	56%	56%	57%
Somewhat helpful	35%	32%	28%	36%	33%	33%
Not helpful	2%	4%	5%	4%	5%	4%
Not sure	7%	9%	7%	4%	7%	7%

FIGURES

Figure 1: Mean assignment and midterm scores based on number of tutorials completed.