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Abstract

This study investigates student success in an online introductory statistics class. We examine the impact of several variables: amount of time that a student watches instructor-made videos (IMV), the nature of communication between the student and the instructor, and the amount of time spent on completing the online assignments and exams on student grades in an introductory level online statistics course. Findings suggest that IMVs of short dur ation, the subject-related communication between the student and the instructor, and homework completion time have significant association with student performance. Though the average time spent on online exams does not show a statistical association with student grades, the results indicate that the students who complete the exam between two-to-four hours perform better than the students who spend less than two hours or more than four hours to complete the exam.

1. Introduction

Due to busy schedules and the accessibility of relevant technology, demand for online education is at the highest that it has ever been. Consequently, the rate at which institutions are starting new online education pro-

grams is increasing. The usage of streaming video for educational purposes started on a large scale in 2008 [14]. Shanley [19, 18] evaluated retention studies in identifying factors for student retention in online courses, and found that support services, early submission of work with instructor feedback and frequent contact, relevancy and accuracy of course content and design, faculty preparedness, age of students, and student participation are some of the main areas that influence student retention in an online course. Furthermore, Holley [10] showed that because of the use of technology, students seem to enjoy online courses more than a face-to-face class.

Videos can be one of the most powerful tools when attempting to replace face-to-face instruction by an online class. Research indicates that videos improve the quality of the course and also enable the instructor to provide a virtual presentation. However doing this well is not an easy task. When developing an online course, one needs to understand the related pedagogical and technological issues, and the communication skills that are necessary to make the course successful.

The ability to effectively incorporate multimedia resources such as text, image, sound, and speech with videos is extremely beneficial. Another major advantage of using videos in education is the student's ability to process the information at her/his own pace. One of the main difficulties that students find in face-to-face classes is that the pace of the class is beyond their control. Hartsell and Yuen [9] argued that the main benefit of videos in education is that the learner can now control the pace at which the content is delivered. 100% of the students in a survey [16] showed their preference for IMVs by showing some level of agreement with the statement, "IMVs helped me understand the material better". Further, the author of [16] argued that though IMVs are beneficial for both online and face-to-face classes, they are 100% beneficial for the online class.

Use of videos is prevalent across many disciplines. Bai and Pan [2] examined the effect of shorter IMVs for business, chemistry, and mathematics courses and found that the IMVs had a positive impact on student performance. Compared to long videos, short videos are more efficient not only from the technical point of view, but they also enhance student attention to focus on the material. When a student pauses a long video and revisits it after a break, it reduces the student's attention, and it may take time to recall what was heard before. Further advantages of using short videos are discussed by Glance *et al.* [21] and Khan [22]. As they suggest easiness

of phase controlling, pausing, rewinding, and returning to the content are vastly beneficial. Glance *et al.* [21] considered the usage of short videos as a pedagogical benefit because it enhances student attention and also helps them to focus on the concepts.

Videos alone will not make an online class a success. Dell et al. [6] argue that a successful online program must address the key issues of student isolation. Therefore keeping students engaged and in sound communication are vital in an online class.

Effectiveness and efficiency give educators the incentive to produce focused presentations which will contribute to learner satisfaction [2**?**]. Focused presentations are the first step in drawing the student into the course material, but effective interaction in an online class also plays a major role. Moore [12] identified three types of interactions in an online class: learner-to-content interaction, learner-to-instructor interaction, and learner-to-learner interaction. Gosmire *et al.* [8] examined the learner-to-content interaction in an online class and found that the female students perceive the interaction significantly better than the male students. In another study, Martyn [11] studied the teacher-student and student-student communication in an online class. In this paper, among other factors, we study the impact of student-instructor communication in an online class.

It would seem that besides the effective use of technology and communication, student engagement should also influence student grades in an online course. Dixson [7] stated that there is no particular activity to engage students in the online class, but to use multiple channels for higher engagement. Beaudoin [3] also stated that student engagement is important for the success in a course, and according to the author's finding the visible learners perform better than the invisible learners in an online course.

One of the main difficulties in studying the impact of student engagement to success in a course is quantifying engagement. Time and effort invested, level of participation, and the amount of communication are some of the variables that researchers have used to investigate the impact of engagement on the success in an online course. Research on student engagement includes the following:

- Davies and Graff [5] indicate that the number of times a student logs into the system (Blackboard) can be used as an effective indicator to quantify the student's engagement.

- In a hybrid course, Rodgers [15] found that time spent online was significantly related to student's success in the course.
- Ryabov [17] studied the importance of time spent online, prior grades, and demographic characteristics of students on the success in an online sociology course. He found that the time spent online and previous grades are the most influential factors on the performance of the students.

The number of hits and the time spent on the course site seem like good indicators to quantify student engagement. Though student success in a course can be measured by means of different indicators, the aim of this paper is to estimate the relative importance of IMVs, the subject-related communication of the student with the instructor, and the time spent for completing online exams as they influence student grades in an online statistics course. For the purposes of this study, student performance is measured and defined by the overall grade at the end of completing the online course. The authors believe, the lack of studies related to online statistics teaching, usage of IMVs in statistics classes, and subject-related communication between the instructor and the student will make this study a novel for online statistics teaching.

2. Description of the Course and the Data

This study was conducted in a regional university in New Mexico, USA. Statistical Methods I is an undergraduate course offered each semester at this university. General Mathematics, Intermediate Algebra, College Algebra, or Calculus I with a grade of "C" or higher is the prerequisite for the course. Students enrolled in Statistical Methods I are typically majoring in Mathematics, Psychology, Accounting, Biology, Communicative Disorders, Information Systems, or Sociology. Usually the maximum number of students in this class is 35. In the catalog, Statistical Methods I is described as a "[b]eginning course in basic statistical methodology: measures of central tendency, variability and association; probability and sampling distributions; estimation of parameters and testing hypotheses."

This particular study was conducted during summer 2013 in an online class of Statistical Methods I. Initially, there were 34 students registered for the class. Instructor-made videos (IMV) were used to deliver instructions to

students and homework was assigned using an online system called MyStatLab. There were three online exams in addition to the face-to-face final exam. The total number of homework assignments was eight. Students voluntarily participated in the data collection, and only 25 students participated in the survey.

3. Methodology

For this study, we prepared short videos using Camtasia Studio 8. These videos contain explanations of statistical concepts and the key calculations. Research indicates that the attention of students' dramatically decreases after ten minutes of listening to lecture [4]. In their study, Glance *et al.* [21] have created short videos according to Khan's claim [22], which states that the optimal time period over which students can maintain attention is 10-15 minutes. Therefore, in this study we deliberately created videos of 10-15 minutes length in time. While presenting theoretical matters, a writing pad was used to explain important calculations of related problems. In addition to this, IMVs explained how to use statistical software (Minitab) to conduct statistical procedures. The videos were uploaded to YouTube and the URLs were sent to the students registered in the class.

The homework assignments and three exams were conducted using MyStatLab software. The comprehensive final exam was administered as a face-to-face written exam.

Throughout the semester, communication between the student and the instructor was conducted through Skype, MyStatLab, the telephone, and email. All communication between students and the instructor was recorded and categorized. Each communication was categorized as whether it was related to the subject matter or not.

Instead of total online time with the course material, the time spent by each student solely to complete each homework and exams was recorded in hours. A voluntary survey was conducted to collect information, asking questions about whether the student watched the IMVs or not, whether the IMVs were useful or not, the number of IMVs watched, and whether the student watched IMVs more than once. Usefulness of IMVs was recorded according to the five-point Likert scale. Multiple regression was utilized with SAS 9.3 to identify the influence of the number of IMVs a student watched, time spent to do homework, the time spent to complete exams, and

the subject-related communication between the student and the instructor on student performance. Student's final grade (out of 100) was considered as the response variable for the above analysis while taking the previously mentioned variables as explanatory variables. One of the drawbacks with the usage of multiple regression on this relatively small sample, is the experience of higher values of standard error (SE) coefficients. An alternative approach based on the kernel re-sampling (KR) technique was proposed by Bai and Pan [2]. Therefore as a confirmation of the estimated coefficients given by multiple regression, kernel re-sampling was utilized in this study.

4. Results

We present our results in Tables 1-3 and briefly discuss them below.

According to Table 1, all the students (N=25) have watched IMVs and they rated the average usefulness of the IMVs as 4.38 (SD=0.77). The average number of IMV that each student watched is 5.71(SD=2.72). Also 92% of the students watched videos in multiple occasions. Collected data reveals that 88% of the students have communicated with the instructor during the semester.

Variable	Mean	SD	Min	Max	Coding
Did you watch the IMVs?	1	0	0	1	0-No, 1-Yes
Usefulness of the IMVs	4.38	0.77	3	5	1- Strongly Disagree, 2- Disagree, 3- Neither agree or disagree, 4- Agree, 5- Strongly Agree
Number of IMVs watched	5.71	2.72	2	8	
Did you watch the IMVs more than once?	0.92	0.27	0	1	0-No, 1-Yes

Table 1: Description of data about IMVs (N =25).

According to Table 2, the average number of times a student contacted the instructor was 4.17 times (SD=2.50). Out of all the communications between the student and the instructor, the average number of communications regarding the subject matter is 3.07 (SD=1.87) and communications that were not related to subject matters is 1.71 (SD=0.92).

Variable	Mean	SD
Number of times contacted the instructor	4.17	2.50
Communication regarding subject matter	3.07	1.87
Communication regarding non-subject matters	1.71	0.92

Table 2: Description of data about communication (N =25).

According to the recorded data, the average time a student spent for each online exam is 2.88 hours (SD=1.29) and the average length of time that a student spent on completing homework is 4.72 hours (SD=2.56).

Independent Variable	Coefficient (MR±KR)	SE Coefficient (MR±KR)	T (MR±KR)
`Constant`	42.18 (-0.01)	5.51 (+0.01)	7.65^{**} (-0.01)
`Number_of_ IMVs`	4.07 (0.00)	0.92 (+0.01)	4.42^{**} (+0.01)
`Homework_Time`	1.46 (+0.01)	0.66 (-0.01)	2.22^{*} (+0.01)
`Exam_Time`	-2.17 (0.00)	1.33 (0.00)	-1.63 (0.00)
`Communication`	2.03 (0.00)	0.68 (-0.01)	2.99^{**} (0.00)

Table 3: The relationship between the factors and student performance (N =25). $** : p < 0.01$, $* : p < 0.05$, $R^2 = 79.80\%$.

Table 3 represents the outcome of multiple regression analysis and kernel re-sampling. This table shows the estimated coefficients, standard error of coefficients, and the T-value under the two approaches of multiple regression (MR) and kernel re-sampling (KR). From the observed MR and KR values, it is evident that both methods have produced very close results in the parameter estimation.

As Table 3 indicates, the number of videos watched and the amount of subject-related communication have positively influenced student performance in the course at the 0.05 level of significance. For the number of videos watched $\beta = 4.07$ and $t = 4.42$ (KR = 4.43), while for communication with the instructor $\beta = 2.03$ and $t = 2.99$.

From these findings, we can also conclude that the time that a student spent to complete homework has significantly influenced that student's performance: $\beta = 1.46$ (KR = 1.47) and $t = 2.22$ (KR = 2.23) at a 0.05 significance level.

According to Table 3, a student's grade is increased by 4.07 points if the number of IMVs watched is increased by one, under the condition that all

other variables are kept constant. Similarly, a student's grade is increased by 1.46 units, if the students spends an additional hour to complete their homework. As far as subject-related communication between the instructor and the student is considered, the final grade is improved by 2.03 if the number of communication is increased by one (assuming that all other variables are kept constant).

Considering these results, it is conceivable that success in the course is influenced by the number of IMVs watched by the student. As far as the suggested model is concerned, 79.80% of the total variation is explained by the above model. Effect size was calculated and according to Cohen's guidelines [20], $f^2 > 0.35$ is a a large value indicating statistical significance.

The results indicate that the influence of the amount of time that a student spent on online exams is statistically insignificant at the 0.05 level of significance. Further analysis reveals that there is a difference in the performance of students in the three categories (A-spent less than two hours, B-spent between two and four hours and C-spent over four hours). Kruskal-Wallis test was conducted to evaluate whether or not there is a difference in the performance of students in the three categories as stated above. The results of this test indicated that there is statistical difference in the performance in each category, $\chi^2(2, N = 25) = 10.602$, $p = .005$. As the Figure 1 indicates, students who spent two to four hours to complete an online exam have performed better than the students who spent less than two hours and those who spent more than four hours.

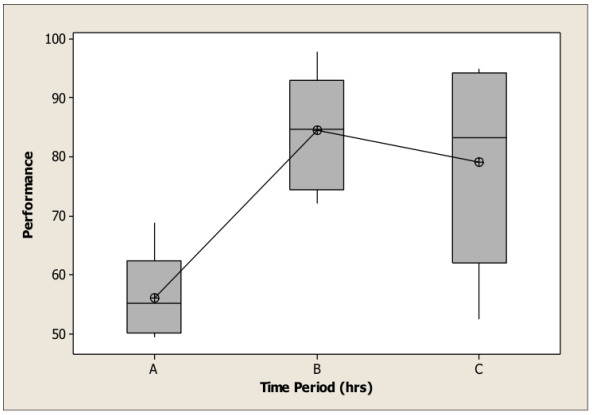

Figure 1: Change of student performance with the amount of time to answer online exam.

5. Conclusion

In this paper our aim was to investigate the effect of instructor-made videos, students' subject related communication with the instructor, and the average time spent to complete online homework and exams on student success in an online statistics class at the college level. Though a designed experiment would be the ideal way to investigate the above relationships and to find the causation, due to practical difficulties, an observational study was conducted.

According to our data analysis, student success in the course is mainly influenced by the number of IMVs that a student watched. In addition, the number of subject related communications that the student had with the instructor during the course and the amount of time spent to complete the homework are also positively significant as far as the final grade is considered. As the literature indicates, IMVs of shorter length can be a powerful tool in online education. The results of this study indicated that IMVs can be effectively used to improve student success in an online statistics class too. Again we reiterate that IMVs should stay focused on key concepts and be short to improve students' chances of learning important material. It is also imperative to use IMVs to explain how to use statistical software.

In addition to the IMVs, our data seem to show that subject-related communication between the student and the instructor positively affected student success in the course. Alternatively it might be the case that stronger and more motivated students tend to seek out opportunities to communicate with the instructor more frequently.

Furthermore, students who performed well in the class have spent more time to complete their homework than others that may have rushed through the assignments. Due to the fact that the number of chances to answer homework is limited, students benefit from utilizing the maximum allowed number of chances given without guessing the answer. So, students who try to complete the homework too quickly can run out of chances to arrive at the correct solution. There may again be other explanations of this result. For instance it might be the case that students who spend more time on the homework learn more from the homework. Or it might be that they are already stronger students who put in extra time. Further investigations are warranted here if we wish to understand this relationship better.

Although there isn't any significant influence of average time spent completing an online exam on student success in the course, we have already noted that the students who spent two to four hours on the exam performed better on it than those that spent less than two hours and those that spent more than four hours. This seems to indicate that students who were better prepared for the exam took two to four hours to complete the exam, while those who were not prepared took more time to try to recall the information. Also, some of the students who were not prepared for the exam may have completed the exam in less than two hours because they were unable to answer all of the questions.

We acknowledge that a larger sample size would be better for this type of investigation though the effect size indicates a larger value according to Cohen's [20] guidelines. In addition, agreement between the estimated coefficients of multiple regression values and the kernel re-sampling values indicates that the sample size has not become an issue in this analysis.

We expect to conduct further studies on factors that influence student performance in statistics courses as it is beneficial to identify the factors for student retention in statistics classes. Finally, we recommend instructors of online statistics courses to use short IMVs effectively, inform students of the values of communicating with the instructor especially over the subject matter, encourage students to watch them multiple times until they digest the concepts, and to spend allocated time to complete homework accurately without rushing.

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