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Effect of Online Recorded Video "Review Session" on Student Test Preparation and Performance for Fluid Mechanics Midterm at a University in the Netherlands

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There is an increasing push to add more digital resources (such as video lectures) to undergraduate engineering courses, enabling strategies such as the flipped classroom or formats such as online education. Yet in this rapid push, it is important that educators remain circumspect about new methods until they have been proven effective. While online videos have been proven very useful in various lecture scenarios, the purpose of this study was to determine whether a video "review session" may be effective preparation for midterm exams.

At a University of Applied Sciences in the Netherlands, Fluid Mechanics is a part of the first-year curriculum for both Chemistry and Chemical Engineering students. In 2015, an online video was generated based on prior-used material for midterm review sessions and shared with two of the four sections. The hour-long exam comprised four multiple-choice questions on theoretical concepts and two multi-part computational problems in which students solved for quantities like volumetric flow rate and pressure drop. Also printed on the exam paper after the problems was a brief, six-question survey asking about the students' manner of preparation (attendance, book usage, and use of Learning Management System (LMS) materials), whether they watched the video, and what sort of math and physics they had had in their high school courses and exit exams. Only one student, of the eighty-one tested, did not answer the survey questions.

Interestingly, the students who obtained the video from the instructor (40% of students) scored lower on the 10-point grading scale than those who did not—a 5.77 average for the former group compared to 6.22 for the latter; while the two students who answered that they had obtained the video from a fellow student rather than from the instructor averaged a 5.05. The survey results showed that a majority of students who reported watching the video also reported not using the online materials (consisting of practice exams with solutions): 19 did not use the LMS materials, out of a total of 32 who watched the video. For the control group (those who did not watch the video), this proportion was fifty/fifty (24 out of 48). While these results may not be statistically significant, it suggests that many students who watched the video used it as a *replacement* for other study methods rather than as a *supplement* to them. While the use of this video may have worked to these students' detriment, it should be noted that much stronger indicators of student success on the exam included class attendance, whether they purchased or obtained the book, and whether or not advanced math geared toward the physical sciences was a part of their high school exit exams.

Introduction

Many universities offering degrees in the STEM disciplines are exploring all available options when it comes to using the internet to, for example, cater to students' individual learning styles. This new age of learning has opened doors for professors to reach students in new ways outside of the classroom, leading to the rise of online tutoring and courses such as edX, Kahn Academy and of the flipped classroom teaching technique, where course lectures take place entirely in videos online, either live or pre-recorded. This increase in the number and diversity of resources available to students of all learning styles is a key strength of online pedagogy. Nevertheless, it may not be the cure-all some would like it to be as it may, in some cases (e.g., when provided without context or directed instruction), actually be a hindrance to some students' learning. The primary objectives of this paper are to determine the impact, negative or positive, of professor-created videos and past math and science experience on success on a fluid mechanics exam.

The most popular method to help engineering students online has been the provision of problem-solving videos, often posted on the Learning Management System (LMS) (e.g., Canvas, Blackboard), because it allows students to watch at their own pace and typically allows for visualization of the problems [1]. Viewership of videos typically peaks around exam times, indicating that students are using the videos to prepare for tests [2]–[4]. Research has shown that the majority of students generally enjoy learning through videos [2], [4]–[7]. Approximately 70-85% of students report that they find videos helpful and useful [2], [4], [5] Though such videos may be well-liked, it is important to bridge the gap between how the use of videos relates to the grades received by students. Some past research shows that student performance improves from video use [5]–[12], others show that there is little or no correlation [2], [13]–[15], and some that students even do worse than with traditional teaching methods [2], [3], [16], [17]. Thus, the effectiveness of online videos is unclear, and should be examined further. Specifically, evaluating the effectiveness of exam preparation videos in a Chemical Engineering curriculum is the primary objective of this paper.

In addition, there is little literature evaluating whether a student's past experience with math and science courses can have an impact on Chemical Engineering success. In a study of physics students, those who had taken a high school physics course showed improved success in college-level physics relative to those who had not [18]. Still other studies have found that the primary factor in determining first year GPA in Engineering is overall SAT scores [19]. Still, these correlations are weak and not necessarily applicable to Chemical Engineering students. Since there is a large gap between identifying engineering success in higher education based on previous scholastic experience, this paper will also use Chemical Engineering students to bridge that gap. Another objective of this paper is therefore to compare the correlation between prior preparation (high school) and exam scores, against that between video viewing and exam scores.

Methods

The participants of this study were 80 students enrolled in a 2014-15 Fluid Mechanics course for Chemistry and Chemical Engineering students at a University of Applied Sciences in the Netherlands. This course is a required part of the first-year student's curriculum, for both majors. There were four sections in total, but only two of the four (one taught by each professor) were provided access to a series of two midterm review videos, posted to YouTube by one of the professors. The first of these videos is a traditional conceptual review lecture, nearly ten minutes long, covering topics such as volumetric flowrate and the various measures of pressure head [20]. The second walks through the solutions to three different practice problems before reviewing the types of Non-Newtonian fluids, running just over nine minutes long [21].

The hour-long exam contained a Theoretical (30 points) and a Computational section (50 points). Students receive a minimum of 10 points (a grade of 1.0 in the ten-point grading scale used in the Netherlands) for their presence at the exam. The Theoretical section consisted of four multiple-choice questions—two of which had two correct answers—with each correct answer worth five points. The computational section consisted of a three-part question on Bernoulli (pressure, velocity, and volumetric flowrate) worth 29 points, and a two-part question on laminar flow (pressure drop and diameter). In addition, there was a 10-point bonus question as a follow-up to the last problem. Thus, a perfect scoring student could have obtained 110 points, in total (though none did). Finally, a survey was printed at the end of the exam (on the same page as the exam questions). A translation of this survey is depicted in Table 1. This not only yielded data on how students prepared for the exam, but also on each student's curricular background in high school.

Question	(a)	(b)	(c)	(d)
1. Did you attend all classes?	Yes, or mostly (with few exceptions)	Yes, but I didn't stay the whole time (90 min)	Not often, no	Not at all
2. Did you buy the book (Potting, "Stromingsleer"), or otherwise have access to it?	Yes, I bought it (new or 2nd hand)	Yes, I have a digital version of the whole book	Partially, I have a digital version of some sections	No, not at all
3. Did you watch the review video? (it was only sent to 2 of the 4 sections)	Yes, via a link in an email from the instructor	Yes, via a link from another student	No	
4. Did you use the problem solutions on Blackboard to study?	Yes, I tried the problems first, and then I looked at the solutions	Yes, I've looked at them (printed or digitally), and used them to study	No	
5. If you were a HAVO-student in high school, was 'Math B' a part of your graduation exams?	Yes, it was	No, it wasn't	N/A (did not graduate as a HAVO-student)	
6. If you were a HAVO-student in high school, was Physics a part of your graduation exams?	Yes, it was	No, it wasn't	N/A (did not graduate as a HAVO-student)	

Table 1. Survey questions (translated) listed immediately after the midterm exam questions, and their answers.

The respondents' answers to this survey are compared to their test scores (both as a whole group and divided into various sub-groups) using swarm plots of individual student scores in each group (based on their answers to a given question), super-imposed over bar charts depicting the average score for this group of respondents, with error bars providing the standard deviation. Note that the grades (even of individual sections: Theoretical and Computational) are all normalized to the ten-point grading scale used in the Netherlands, for purposes of cross-comparison.

Results and Discussion

The videos were used, much as the literature suggests, most frequently on the days just prior to the exams. Figure 1 depicts the YouTube access data for both videos from the date of posting, January 5th 2015, through the regular scheduled final exam for the course, January 28th 2015. The midterm exam for which this video was intended took place on January 7th 2015.

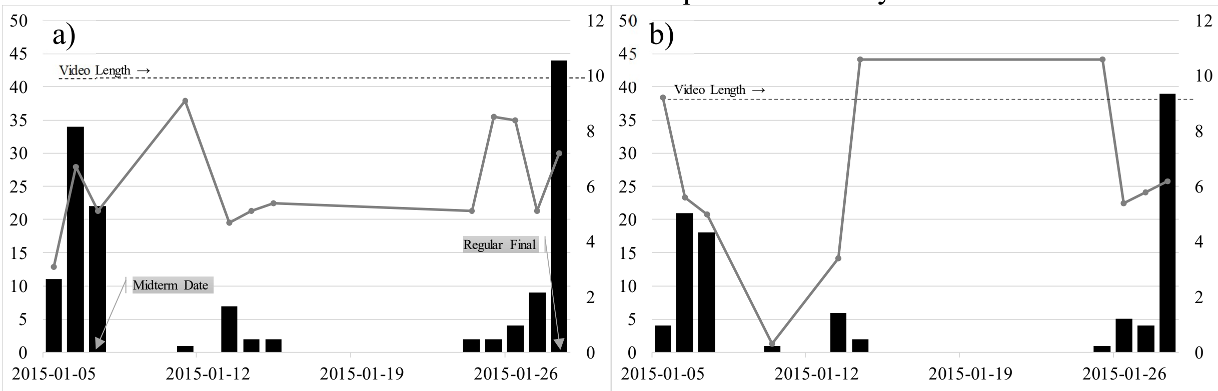

Figure 1. YouTube data for a) Video 1: concept review, and b) Video 2: example problem solutions, with the number of daily views (left axis) and average view duration in minutes (right axis) on days with a non-zero number of views.

When comparing the two figures it is evident that, while the first video received more total views (375 vs. 246) during the three days leading up to the midterm, the second video was viewed for longer periods of time (averaging 5.7 min, compared with 5.6 min for the first video), especially as a percentage of the video length. Finally, these data reveal that students are not using the videos very much during the period between exams—mainly only after receiving their returned exams (on January 12th 2015).

Overall, the survey printed directly on the exam paper was successful in obtaining a high response rate, with 80 of the 81 tested students responding to every question. (The scores of the one student who did not respond to the survey were eliminated from the dataset and all analysis below). The exam average for all four sections was a 6.02, with a standard deviation of 1.51. The average exam grade and standard deviation for each group responding a, b, c, or d (where applicable) are summarized in Table 2.

In the responses to Question 1, it is clear that the majority (67 of 80) of respondents reported attending class regularly, for the full class period (there was usually a 5 min break in the middle of each 90 min class). Furthermore, there is a notable difference (0.27) between this group and those students who leave early or do not attend often (possibly recidivist students, not taking this course for the first time, or high-achieving students who do not require class to learn the material). Figure 2 depicts the results of this question for only the Chemical Engineering (ChemE) students, revealing that the three ChemE students who did not attend class for the full time scored significantly worse than those who attended regularly, while those ChemE students who did not often attend class scored very well.

Survey Question		(a)	(b)	(c)	(d)
Question 1.	Average Exam Score	6.10	5.10	5.83	-
(67/4/9/0)	Standard Deviation	1.54	1.63	1.22	-
Question 2.	Average Exam Score	6.65	5.70	6.33	5.68
(11/1/26/42)	Standard Deviation	1.36	-	1.41	1.56
Question 3.	Average Exam Score	5.77	5.05	6.22	N/A
(30/2/48)	Standard Deviation	1.56	0.35	1.49	N/A
Question 4.	Average Exam Score	5.81	5.73	6.21	N/A
(21/16/43)	Standard Deviation	1.60	1.29	1.53	N/A
Question 5.	Average Exam Score	6.11	5.37	6.27	N/A
(49/13/18)	Standard Deviation	1.53	0.92	1.72	N/A
Question 6.	Average Exam Score	5.98	5.33	6.27	N/A
(59/3/18)	Standard Deviation	1.44	1.83	1.72	N/A

Table 2. Average exam grades and standard deviations, organized by survey question, for all respondents. The number of respondents in each answer group (a/b/c/d) are listed below each Question #.

In examining the data for Question 2, the conventional assumption is confirmed that students who do not have access to the book (either digitally or in printed form) perform notably worse on exams. It is worth noting that the students who only had digital access to portions of the book performed nearly as well as students who had the printed book (the former 6.33, the latter 6.65). It is also important to note that over half of the respondents (42 of 80) reported not having access to the book at all.

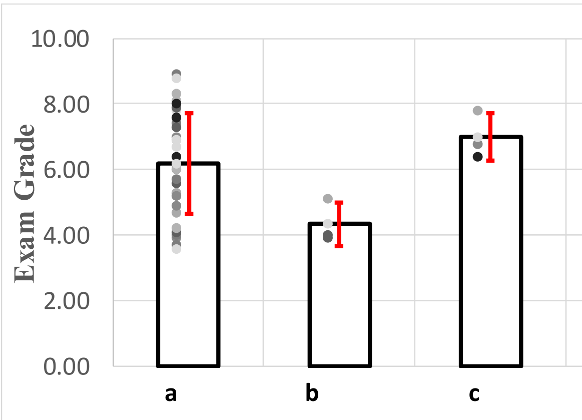

Figure 2. Exam results for ChemE students sorted by answers to Question 1 (attendance): (a) Yes, (b) Yes, but didn't stay, (c) Not often.

Figure 3 depicts the Exam grades and (normalized) grades on the Computational section alone, for the groups of respondents to Question 2. These show the greater effect of owning the book for the computational section than for the final exam grade (and thus, for the theoretical section as well), with an average Computational score of 8.08 for answer (a) vs. 5.20 for answer (d).

The analysis of the data from Question 3 was the primary goal of this study. Table 1 shows that students who viewed the review video did worse by 0.45 points, on average. While this difference is less than a third of a standard deviation, and thus not significant (see t-test results, below), this result is a surprising one and merits a complete discussion.

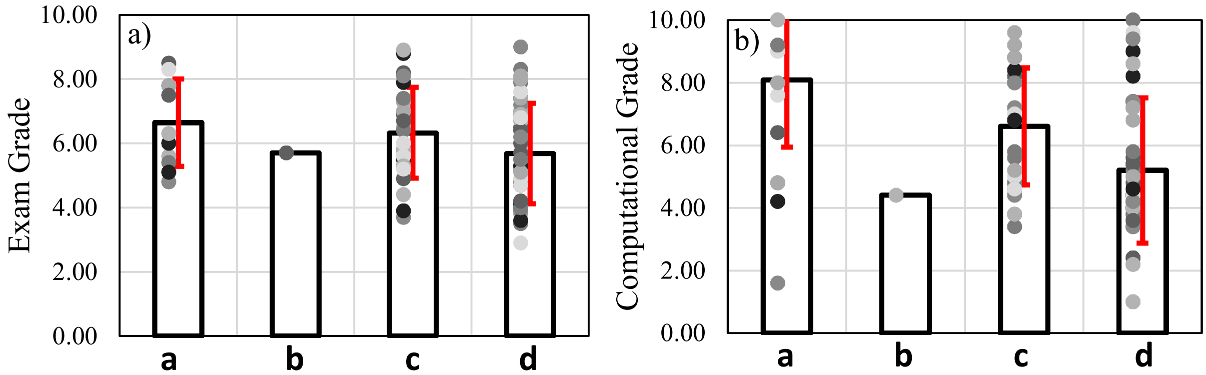

Figure 3. a) Exam final grade and, b) grade on the Computational section only (normalized to the 10-pt scale), grouped by responses to Question 2 (book access): (a) Paper, (b) Digital, (c) Partial digital, (d) No book.

Most professors would like to believe that a review video can *only* be beneficial to student's learning, but these data reveal that this was not true in this case. Possible causes for this phenomena include: students did not follow along the video, leading to a passive state of learning which is far less effective than following along and trying to work the problem on their own before using the video for help; students perceived the video to be a near replica of the exam, so they mastered only the specific problem types and topics covered in the video; students felt that the video was a replacement for traditional exam preparation, and neglected studying the material in other ways (e.g., using the LMS); students used the video as their only source of preparation for the exam (see discussion of Figure 4, below); or, the video was of such poor quality that it actually harmed students' understanding. This last possibility may be eliminated as the video has since been reviewed by several colleagues, and the penultimate possibility is eliminated below, leaving three likely scenarios: passive learning, learning-to-the-test, or using the videos as a replacement to traditional study. There may, of course, be still other possibilities, but the data collected in this study are not sufficient to identify all of them.

A student t-test analysis on Question 3 for yes responses (including both responses a and b) using a 95% confidence interval yields the value of 2.04. This value can be interpreted to mean that any student has a 95% probability to have an exam score between 3.73 to 7.81 of 10. This is a very large range, essentially from a failing student (5.5 is a passing grade) to a B-. The same test was run on the students that had not watched the video, and the t test value was 2.01, or a range from 4.21 to 8.23. These t-test results and the standard deviation data not only demonstrate that the difference between these groups is not large enough to be considered significant, they also support the notion that a simple average of students is a poor method to evaluate the exam results. Some students do not need the extra help and perform highly, while videos and Blackboard problems may not be the help that struggling students need. This is why the authors have included swarm plots (and not just average and standard deviation data).

Question 4 is fairly comparable to question 3 in that they both probe the respondents' use of additional resources provided by the professor. The results of both questions showed the same trend: students who *did not* use the problems provided on the LMS to study actually performed better by an average of 0.40 points. This difference is even smaller than that for Question 3, and the standard deviations for Question 4 were also larger, indicating that this difference is even less significant than in the prior question.

In an attempt to unravel the puzzling results of Questions 3 and 4, the groups of students who had watched the video (Question 3, a and b) and had not watched it were further broken up into those who had used the LMS problems (Question 4, a and b), and those who had not—creating four groups in total. The final exam grade data for these groups (a = affirmative, c = negative) is shown in Figure 4. This figure demonstrates that students who used the least number of online resources (LMS or video) received the highest grades. This is further evidence that students who study the most, or use the most online resources, are not necessarily the same ones who perform the best.

However, the data in Figure 4 also reveal that the groups are disproportionately distributed; that is, while the video-watchers were roughly half of the class (the left two data sets in the Figure, 32 students), a disproportionate number of them *did not* use the practice problems provided on the LMS (19 students). Among the non-video watchers, this was exactly evenly distributed (24 students, each), suggesting that video-watchers were less prone to take advantage of the other online resources. This is an important conclusion that will be discussed in the following section.

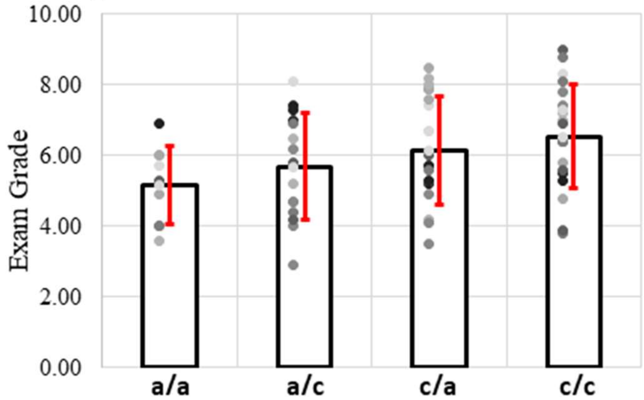

Figure 4. Exam grade data based on the composite answers to Questions 3 and 4, on watching the video and using LMS, respectively. (Answers a and b were both counted as "a" or Yes, while "c" is No.)

Another plausible cause of these counter-intuitive results is that some students have a stronger background in math and physics, which are utilized throughout engineering courses and may have had an outsized effect on these exam results. Questions 5 and 6 offer insight into this effect. Question 5, regarding high school Math B (roughly equivalent to Calculus AB in the US), shows that HAVO students who had Math B on their high school exit exams did 0.74 points better, on average, than those HAVO students who did not. Similarly, HAVO students who had Physics on their graduation exams did better by 0.65 points than those who did not. Although still not larger than a standard deviation, these differences are much more significant than those in Questions 3 and 4. This supports the notion that students with firm roots in math and physics perform better in future engineering courses, and furthermore that prior preparation and performance (in math and physics) are better predictors of success in a Fluid Mechanics midterm than access to online

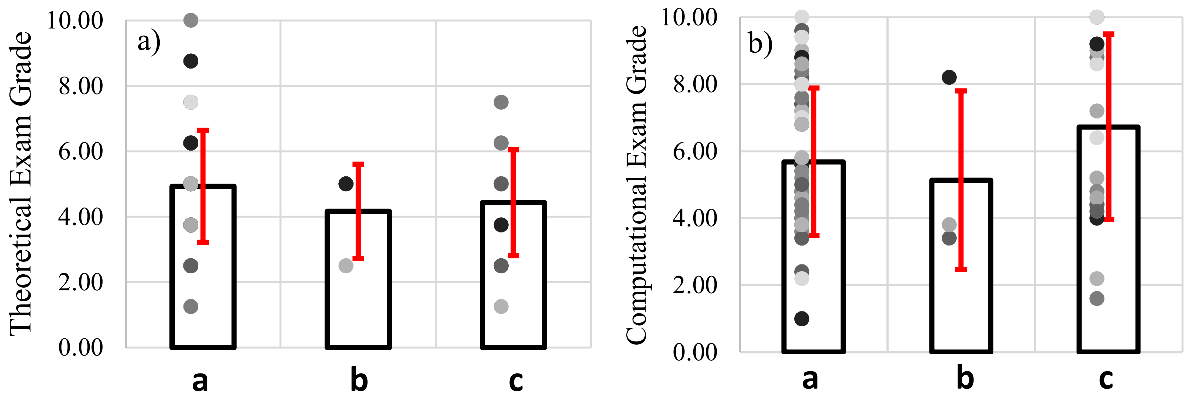

Figure 5. Normalized grades on a) the Theoretical section, and b) the Computational section of the midterm exam, grouped by responses to Question 6 (high school Physics).

materials.

Interestingly, students who did not graduate high school in the HAVO track did better than the students who did. These students either recently graduated high school from the higher, more academic track (VWO), or they graduated from the lower, more vocational track (MLO) *and* have since completed the equivalent of an Associate's degree in order to study for their Bachelor's.

Figure 5 displays the effect of HAVO-student physics background on the average scores in the Theoretical and Computational sections of the exam. Students who had had physics as a part of their exit exams scored better on the Theoretical section (4.93) than both those without Physics (4.17) and non-HAVO students (4.43). This performance was not seen in the Computational section, where there was little difference between those HAVO-students who had physics and those who did not. Non-HAVO students performed notably better on the Computational section. (Note: Because of the truncated points in the Theoretical section, grades are in multiples of 1.25 only. Figure 5a does indeed include all students in the plot, but many of the data points overlap exactly.

Conclusions

The authors engaged in this project because of their interest in developing more, and more effective, videos for use in Chemical Engineering curriculum. Yet this research yielded a surprising result: namely, that videos used for midterm preparation may actually be detrimental to average student performance, for various reasons. While this effect was not statistically significant, it is nonetheless a cautionary tale warning against the assumption that the production of such videos is necessarily worth the time and effort. In this case, these students may have been better served by an in-person review session or by additional office hours by the instructors. In fact, while these videos remain available online to this day (and continue to be viewed by students following this course), the author has added a warning message to the video description, explaining that the videos are not a *replacement* for normal study, but rather to be used as a *supplement* to the arsenal of study methods at their disposal. The warning goes on to encourage students to use all available resources to study including the textbook, notes, and materials provided on the LMS.

In addition to adding a warning to students on how to (effectively) use the videos, the instructor may wish to motivate the student in other ways. Based on anecdotal experience, students seem more likely to simply scroll through practice problems or put a video on in the background if they are not incentivized to problem solve on their own. This may be overcome by, for example, making interactive interfaces where the user is required to input a correct answer before moving on in the video or problem, essentially gamifying the video experience. This could improve the performance of students who watch these videos in preparation for an exam.

This research has also demonstrated that prior experience, for example in high school math and physics, is a better predictor for success on a first-year fluid mechanics midterm than is the exposure to online learning materials such as practice problems (via the LMS) or online review videos. This suggests that prior performance (e.g., grades) and not just experience may be among the best predictors available. Finally, the data have confirmed that student performance on a midterm exam is most significantly impacted by whether students attend classes regularly and for the full duration of the class, and whether they have access to the book—although it does not seem to matter much if that access is to a digital copy or to a printed copy.

In conclusion, it is clear that more study is required to elucidate the relationship between online videos for exam preparation and student performance on exams. This research has been repeated for a midterm exam at a University in the United States where Fluid Mechanics is a part of the second-year curriculum, and the results will be compared to those presented here in an upcoming paper. But to yield more definitive, statistically significant results, this research should be performed on a much larger scale (i.e., with a much larger sample size).

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