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Student Preference of Video Length for Studying Machine Learning in a Flipped Classroom

Dr. Ahmed Dallal, University of Pittsburgh

Dr. Dallal is an assistant professor at the department of electrical and computer engineering, University of Pittsburgh, since August 2017. Dr. Dallal's primary focus is on education development and innovation. His research interests include biomedical signal processing, biomedical image analysis, computer vision, machine learning, networked control systems, and human-machine learning.

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Abstract

In recent years, the flipped classroom has emerged as an increasingly popular teaching method in higher education, as it is seen as an effective way to promote active learning among students. Nevertheless, a crucial factor that has not been studied in-depth is students' preference for the length of videos in the flipped classroom. Although a few studies have considered the design process of videos and students' preferences for video length in a flipped classroom, there are varying recommendations and a lack of data-driven analysis on how many and how long the videos should be. In this study, we investigated students' preference for video length in flipped machine learning classes offered during the spring and fall semesters of 2022. The flipped modules of this course include video lectures that vary in length, ranging from 4 to 20 minutes. Depending on the video's length, we required students to finish between three to seven video lessons before class time. To analyze student interaction with videos of different lengths, we statistically analyzed the video coverage from different modules and used surveys to gather students' preferences for video length. Our analysis indicated that the number of students completing videos before class time significantly decreased as video duration increased. However, once students started a video, they completed most of it irrespective of its length. Statistical analysis of homework scores did not show any significant difference in students' performance in modules with short videos compared to those with long videos. In response to the survey, a considerable percentage of students indicated their preference for short videos, as it helped them maintain focus. However, a higher percentage of students acknowledged that despite the varied video durations, the lengths were suitable for the presented topics. This suggests that relatively longer videos could be acceptable if the nature of the topic requires it. However, these videos should be interactive to help maintain students' attention.

1. Introduction

Active learning showed effectiveness in enhancing student problem-solving skills, conceptual gains, exam scores, and engagement [1], [2]. Despite the known benefits of active learning, lecture-based teaching in STEM is still the prevalent approach, with active learning, in general, propagating at a slow rate [2], [3]. However, with advances in technologies and ideologies, online education has gained more popularity and acceptance among students. In addition, With the transition to remote education due to COVID-19, the flipped instruction style gained more popularity among instructors [4]. Instructors found that they could tailor class time to students' needs in remote classes.

Flipped instruction is a student-centered, more involved form of active learning that aims to increase students learning and the quality of activities during the class period. Bishop and Verleger [5] defined flipped pedagogy as interactive group-based learning activities occurring inside the classroom and direct computer-based individual instruction occurring outside the classroom. Students are provided opportunities to practice their knowledge in class with the guidance of an instructor. Thus, flipped instruction could help teach machine learning courses, e.g., [6]. Students can watch videos that cover the algorithms before class meetings. Then, during class time, the

instructor can address the student's concerns and questions, run demos to visualize the studied algorithms, and go over practical considerations for implementing these algorithms. Overall, an immersive experience that fosters student engagement with the course content and enhances learning through diverse class activities and discussions.

Literature on the flipped classroom considered different methodological treatments. However, most of the findings are consistently encouraging. Previous research suggests that student learning is likely to improve in the flipped setup compared to the traditional classroom [5], [7]–[9]. Much of the existing research assessing the effectiveness of the flipped classroom in higher education contexts (a) compares a flipped course to previous, more traditional iterations [10]–[12] (b) utilizes pre-post designs assessing changes from the beginning of the flipped course to the end [13]–[15], or (c) focuses on student perceptions and satisfaction with the flipped approach [16], [17].

However, given the students' continued resistance to flipped instruction [2], [3], [5]–[8], [17]–[19], there is still much to be learned about the best practices for creating and delivering flipped classroom lectures. One important factor to consider is the length of the video lectures. Research has shown that student preferences for video length vary depending on the subject matter and the student's learning style. For example, a previous study [20] found that students preferred shorter videos (less than 10 minutes) for topics that were more conceptual in nature, while they preferred longer videos (over 10 minutes) for topics that were more procedural in nature. This suggests that instructors should tailor the length of their videos to the content they are teaching. In addition to the content of the video, the length of the video can also be affected by the student's learning style. For instance, Kizilcec et al. [20] found that students who preferred a more active learning style (e.g., those who preferred to take notes while watching the video) preferred shorter videos, while those who preferred a more passive learning style (e.g., those who preferred to watch the video without taking notes) preferred longer videos. This suggests that instructors should consider the learning styles of their students when deciding on the length of their videos. Finally, the length of the video can also be affected by the student's level of engagement [21], [22]. Students who were more engaged with the video (e.g., those who watched the video multiple times) preferred longer videos, while those who were less engaged with the video (e.g., those who only watched the video once) preferred shorter videos [20]. This suggests that instructors should strive to create videos that are engaging and that encourage students to watch them multiple times. Hence, the author was motivated to study the student preference for the length and number of videos used in their flipped machine learning course. The research questions that the author investigated are as follows: 1) What is the ideal number and length of videos for a flipped module as designed by instructors? 2) Are students more likely to complete modules with shorter videos? 3) Do students perform better in modules with shorter videos? 4) How probable is it for students to finish a longer video if they begin watching it? 5) Do pre-class accountability quizzes serve as a good motivator for students to watch the video lectures?

In this paper, to address the aforementioned research questions, we study students' average view time, video coverage, and their preference for the number of videos and the length of videos used in the flipped machine learning course offered in spring 2022 and fall 2022 at the department of electrical and computer engineering (ECE), University of Pittsburgh. To accomplish this objective,

we used statistics from the university's video management system, Panopto, and anonymous student surveys. In addition, we also study students' performance in modules with longer videos versus their performance in modules with shorter videos. To assess student performance, we conducted statistical analysis on their homework scores from assignments with different video lengths.

The various assessment and data analysis methods used in this paper to capture students' interaction with video lectures in the flipped machine learning classroom are introduced and referenced in the Methods section, including methods for statistical analysis and qualitative data analysis. Quantitative analysis of students' scores in short-videos vs. long-videos modules, and summaries of the average viewing time and the frequency of viewing videos for each module are presented and discussed in the results section. Also, student perspectives on the design of flipped classrooms are analyzed and discussed in the results section.

2. Methods

2.1. Course Description and Instructional Pedagogy

This study focuses on the machine learning course offered at the ECE department of the University of Pittsburgh. It is an elective 3-credit course with an average enrollment of 30 students per semester. The course covers theoretical concepts and practical considerations related to various machine learning algorithms, such as linear regression, logistic regression, support vector machines, and neural networks. The course is divided into equally challenging modules, with each module focusing on one algorithm. The data for this study were collected from two partially flipped offerings of the course, where half of the modules were flipped. The data was collected during the spring semester of 2022 with an enrollment of 35 students and the fall semester of 2022 with an enrollment of 19 students. Both semesters were held in person, and all class activities were conducted in person.

According to research, a successful active learning framework should take into account how students come across new information and ideas, how they interact with them, and how they reflect on their learning [23]. In our study, we used a flipped pedagogy approach, which involved the following:

i. Introducing new material to students through video lectures that presented machine learning algorithms. Students were required to watch between three to seven video lectures, each ranging from 4 to 20 minutes in length, before attending class. During class, the algorithms were reinforced through demos.
ii. Encouraging student engagement with the material through in-class discussions and demos.
iii. Promoting student reflection by asking them to answer warm-up questions related to the video lectures at the beginning of each class.

Furthermore, we employed short accountability quizzes to evaluate students' comprehension and encourage them to complete the video lectures prior to class meetings. These quizzes consisted mainly of multiple-choice questions and were administered through the course management system, Canvas, enabling students to receive immediate feedback on their performance.

Programming homework assignments were also utilized to further gauge students' learning. Our approach and evaluation methods align with the components of the flipped classroom model as defined in [24].

2.2. Analysis of Video Coverage

The videos for each flipped module were available online on the university's media management system, Panopto. Links to these videos, module slides, and supplemental materials were available on the course website on Canvas, at least one week before the scheduled class meeting of that module. We classify videos shorter than 10 minutes long as short videos, and videos longer than 10 minutes as long videos. Modules with short videos require students to finish five to seven videos before class time, while modules with long videos require students to finish two to four videos before the class meeting. We used Panopto's video statistics to analyze the average viewing time, the frequency of viewing videos for each module, and the percentage coverage of each video, since not all students complete the videos in their entirety. We combined the data from the two sections and performed a two-sample t-test to statistically compare the coverage of short and long videos.

2.2. Direct Assessment of Student Performance

Since all modules are of comparable difficulty, the homework assignments were used to assess the student performance in the modules with short videos vs. their performance in the modules with short videos. The scores from the two sections were combined to increase the sample size for statistical comparison. The scores were compared using paired samples t-tests and Glass' Delta effect sizes. Glass' Delta effect sizes were calculated to determine the practical significance of the differences, with values below 0.50 considered small and values of 0.80 or above large [25], [26]. Glass' Delta is often used in the case of paired samples [27]. In addition, the non-parametric analog to the *t*-test, the related-samples Wilcoxon signed-rank test, was run to corroborate the results of the *t*-test given the smaller sample size ($n = 54$) [28].

2.3. Assessment of Student Perspectives

Student perspectives on the number and length of video lectures were acquired each semester by conducting anonymous surveys. Also, the survey asked about the effectiveness of the videos to achieve the posted learning outcome for each module and whether the accountability quizzes served as a good motivator for the students to complete the videos before class time. The survey questions are shown in Table 1. The student surveys were collected towards the end of the semester and before the final exams. Human subjects' approval (PRO18060710) was secured for these various forms of student assessment Participation in the surveys was voluntary and no incentives were given for participation. The data from the two sections were combined to increase the sample size for content analysis associated with each question for each item. In total, thirty-nine responses were collected and analyzed (72% response rate). The first and fourth questions' responses were in a free form and were content analyzed using a coding scheme similar to those developed as part of previous studies [8], [29], [30].

3. Results and Discussion

3.1. Video Coverage Statistics

Table 2 shows the average video coverage statistics for the video lectures used in this study. The average duration for short videos was 6.08 minutes while the duration of long videos averaged at

Table 1. Survey Questions

For flipped lectures, you had to watch a series of videos that cover the topic under study. What do you think about the number of videos and the length of them?
On average, on how many sessions did you finish the video lectures for each module?
How likely will you rewatch the video lectures in preparation for your final exam? (5 is highly likely, 1 is less likely)
Were the recorded videos helpful in achieving the learning outcomes of the flipped lectures?
For the flipped lectures, you were asked to watch videos and then complete an accountability quiz at the beginning of the class. Did these quizzes motivate you to finish the video lectures?

Table 2: Average Statistics for Video Coverage.

	Short Videos	**Long Videos**	***p-value***
Duration (minutes)	6.08 minutes	13.74 minutes	<0.005*
% Covered duration	93.71%	92.99%	0.54
% Unique viewers	75.45%	68.85%	0.04*
% Students viewed a video more than once	16.06%	15.27%	0.4

* Difference is statistically significant

13.72 minutes. For both types of videos, students watched more than 92% of the video content. However, the number of students who watched the short videos is significantly larger than the number of students who watched the longer videos. The percentage of students who skipped watching the video increased as the video length increased. Suggesting that the video length is a key factor in motivating students to complete the pre-class videos. The percentage of the students who re-watched the videos more than once remained almost the same despite varying the video length. Thus, we can conclude that re-watching videos is a factor of students' learning style rather than depending on the video length.

Regardless of the video length, approximately 25% of the enrolled students, on average, did not watch any of the flipped modules' videos before their scheduled class meeting; ought to their resistance to flipped instruction and a perceived feeling of an increased workload. This problem was reported in multiple studies, e.g., [2], [3], [5]–[8], [17]–[19]. Thus, besides designing videos of proper length, more incentives should be offered to motivate the students to complete the pre-class videos on time.

3.2. Direct Assessment of Student Performance

Table 3 shows the statistical analysis of the average homework scores from modules with short and higher on the average homework scores from of videos vs the average homework scores from modules with long and less number of videos. The homework scores in the modules with shorter videos are slightly higher than the assignments in modules with longer videos. However, this difference is not statistically or practically significant, as shown in Table 3. Thus, the students on average could perform well on the class assignments regardless of the video length.

Table 3: Average Homework Score Comparison between modules with a short length but a large number of videos vs modules with a longer but less number of videos ($n = 54$).

	Mean Score (100)		*p-value*		Effect Size
	Modules with short and more videos	Modules with long and fewer videos	Paired Samples *t*-test (parametric)	Wilcoxon Signed Rank test (non-parametric)	Glass' Delta
Homework	78.03	73.66	0.57	0.31	0.12

3.3. Assessment of Student Perspectives on Class Activities and Flipped Learning

The first survey question in Table 1 gathered students' perspectives on the length of video lectures and the number of videos in each module. Based on a content analysis of the collected 39 responses, 39% of the responses preferred shorter videos over the longer ones. They indicated that they were fine with the high number of videos per module but the shorter videos enabled them to focus on one concept at a time while taking breaks in between the videos. On the other hand, 15% of the participants went in favor of longer videos and wished that all modules were offered in a long video format. Their reasoning was mainly about longer videos enabled them to plan a stronger commitment to finish the module while connecting all concepts together without the need to jump between videos or spreading them over multiple viewing sessions. Finally, 46% of the participants indicated that they did not find a significant difference in preparing and studying long videos vs. the shorter one. They acknowledged that the count and length of videos of each module were right for the nature of the presented topics. This could justify the slight difference in homework scores in section 3.2. Bradbury [31] suggested to to shift the teaching method every 10 to 15 minutes to maintain student focus. The short videos naturlly implemnt this kind of shift and allow the students to to refresh their attention span as they move from one video to another. However, if designed approperiatly, longer videos could still maintain the student attention span. Our students appreciated several aspects of the longer videos, such as connecting to previous sections, opportunities for reflection, and short demos. Despite the video length, 46% of the participants finished the videos of each module in one session, while the rest of the participants splitted the viewing of each modules videos over two or three sessions.

When asked about the likelihood of re-watching the videos in preparation for the final exam, 38% of the students indicated that they are likely to rewatch the videos compared to 46% of the students who indicated that they do not plan to rewatch the videos. The remaining students were not sure about their plans for rewatching the videos. However, compared to the results from Table 2, only about 15.5% of the students ended up rewatching the videos. This difference in the number of intended re-watchers and actual re-watchers could be due to the effectiveness of flipped instruction and class activities in elevating conceptual gains. However, further investigations on the motives that determine the need to rewatch videos and the effectiveness of rewatching are required.

The fourth survey question gathered students' perceptions of the effectiveness of the recorded videos in achieving the intended learning outcomes for each module. The majority of the survey participants (85%) found that the videos helped them to achieve the modules' learning outcomes, especially when supplemented with the class activities and demos. This result demonstrates the effectiveness of flipped instructions as a viable approach to teaching complex materials like those taught in machine learning classes. On the other hand, 15% of the participants indicated that they needed to consult extra resources to understand the concepts. In addition, half of these students (~7.5%) noted that videos were not helpful for their learning and that flipped instruction is not the best way for them to learn. The last question on the survey gathered students' opinions on the effectiveness of pre-class accountability quizzes as a motivator to finish the videos. The majority of survey participants (62%) found that these quizzes served as a good motivator for them. They also noted that the immediate feedback helped them identify the flaws in their understanding. On the contrary, quizzes were not a good motivator for 15% of the participant. Finally, 23% of the students neither agreed nor disagreed that the quizzes motivated them to complete the videos on time. It is also important to recall that the results in section 3.1 indicated that roughly 25% of students did not watch the videos on time. Thus, while accountability quizzes and shorter videos can motivate some students, stronger incentives are required to encourage the majority of students to complete pre-class videos.

Based on the results of the last two questions, while only small percentages of students oppose video-based learning, the author believes that more motivation and careful design of instructional videos would help address these concerns with the growing use of flipped instructions in engineering programs.

4. Conclusions

In the age of digital media, video content has become an increasingly popular way for students to learn and engage with educational material. This popularity helped the spread of flipped pedagogy in academic setups. Flipped pedagogy is a more involved form of active learning. However, there is still a good fraction of students who resist flipped classrooms in favor of traditional teaching. Thus, despite the benefits of flipped instructions, there are factors that educators need to take into consideration to present flipping as a more appealing experience to their students. The length of instructional videos is one of the factors that influence student motivation. In this work, we studied the student performance in modules with varying video lengths in a machine-learning course over two semesters. We statistically analyzed their performance in modules with short modules and modules with long videos. We also studied the coverage statistics of course videos. In addition, we gathered students' perspectives on the video length using an anonymous survey. Our analysis showed that students' performance in modules with long videos is comparable to their performance in modules with short videos. The majority of students acknowledged that the pre-class videos, regardless of their duration, helped them to achieve the modules' learning outcomes. However, the percentage of students who previewed the long videos is significantly less than those who previewed the short videos; suggesting that short video length is a motivating factor to finish pre-class assignments in flipped classrooms. However, all the students who started a video, regardless of its length, completed at least 92% of that video. From the student survey, almost half of the students were comfortable with the video length and indicated it was a good fit for the presented

materials, and 39% of the students preferred shorter videos. While short videos are better in general, educators should not be intimidated by designing relatively longer videos as long as they are designed appropriately to account for the student's short attention span. The length of video lectures in a flipped classroom should be tailored to the content of the video, the learning styles of the students, and the level of engagement of the students. By considering these factors, instructors can create videos that are more effective and that better meet the needs of their students. Also, to reduce students' resistance, effective motivators are necessary for a fruitful flipped class experience. As future directions to this work, the author proposes to investigate the effect of using different motivators on video coverage as well as increasing the sample size for more indicative statistical analyses.

References

[1] S. Freeman *et al.*, "Active learning increases student performance in science, engineering, and mathematics," *Proc. Natl. Acad. Sci.*, vol. 111, no. 23, pp. 1–6, 2014.

[2] C. E. Wieman, "Large-scale comparison of science teaching methods sends clear message," *Proc. Natl. Acad. Sci.*, vol. 111, no. 23, pp. 8319–8320, 2014.

[3] M. Stains *et al.*, "Anatomy of STEM teaching in North American universities," *Science (80-.).*, vol. 359, no. 6383, pp. 1468–1470, 2018.

[4] A. Dallal, M. Zaghloul, and A. Hassan, "New Instructors Perspectives on Remote Teaching Methods," in *ASEE Annual Conference and Exposition*, 2021.

[5] J. Bishop and M. A. Verleger, "The Flipped Classroom: A Survey of the Research," in *ASEE Annual Conference & Exposition*, 2013.

[6] A. Dallal, "Evaluation of Students Performance and Perception of Partial Flipping in Machine Learning Classes," in *2022 ASEE Annual Conference & Exposition*, 2022.

[7] A. Dallal, M. Zaghloul, and A. Hassan, "A Study of Students Perspectives on Different Pedagogical Practices for Remote Digital Signal Processing Courses," in *IEEE Frontiers in Education Conference (FIE)*, 2021, pp. 1–5.

[8] A. Dallal, A. Dukes, and R. M. Clark, "Student performance in partially flipped ECE laboratory classes," in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2020, vol. 2020-June.

[9] A. Dallal, "Students performance in remote flipped signals classes," in *ASEE Annual Conference & Exposition*, 2021.

[10] B. Morin, K. M. Kecskemety, K. A. Harper, and P. A. Clingan, "The inverted classroom in a first-year engineering course," in *the 120th American Society of Engineering Education Annual Conference & Exposition, Atlanta, GA*, 2013.

[11] F. Reyneke and L. Fletcher, "The impact of an inverted traditional teaching model on first level statistics students," in *Ninth International Conference on Teaching Statistics*, 2014.

[12] C. P. Talley, "The Enhanced Flipped Classroom: Increasing Academic Performance with Student-recorded Lectures and Practice Testing in a 'Flipped' STEM Course," *J. Negro*

Educ., vol. 82, no. 3, pp. 339–347, Jun. 2013.

[13] S. Bates and R. Galloway, "The inverted classroom in a large enrolment introductory physics course: a case study," in *Proceedings of the HEA STEM learning and teaching conference*, 2012.

[14] N. Sarawagi, "A flipped CS0 classroom: applying Bloom's taxonomy to algorithmic thinking," *J. Comput. Sci. Coll.*, vol. 29, no. 6, pp. 21–28, 2014.

[15] B. Huang, K. F. Hew, and C. K. Lo, "Investigating the effects of gamification-enhanced flipped learning on undergraduate students' behavioral and cognitive engagement," *Interact. Learn. Environ.*, vol. 27, no. 8, pp. 1106–1126, Nov. 2019.

[16] T. A. Schwartz, "Flipping the statistics classroom in nursing education," *J. Nurs. Educ.*, vol. 53, no. 4, pp. 199–206, 2014.

[17] A. Butt, "Student views on the use of a flipped classroom approach: Evidence from Australia," *Bus. Educ. Accredit.*, vol. 6, no. 1, pp. 33–43, 2014.

[18] A. Hassan, A. Dallal, and M. Zaghloul, "A survey-based study of students' perspective on different remote teaching styles during COVID-19," in *ASEE Annual Conference & Exposition*, 2021.

[19] P. Shekhar and M. Borrego, "After the workshop: A case study of post-workshop implementation of active learning in an electrical engineering course," *IEEE Trans. Educ.*, vol. 60, no. 1, pp. 1–7, 2017.

[20] R. F. Kizilcec, E. Schneider, and G. Cohen, "Student preferences for video length in a flipped classroom," *Comput. Educ.*, no. 85, pp. 1–10, 2015.

[21] T. C. Reeves and J. Herrington, "Quality matters: The impact of video quality on student engagement in a flipped classroom.," *Internet High. Educ.*, no. 24, pp. 10–17, 2015.

[22] Y. Liu and C. J. Bonk, "The impact of video format on student engagement in a flipped classroom," *Internet High. Educ.*, no. 24, pp. 1–9, 2015.

[23] L. D. Fink, *Creating significant learning experiences: An integrated approach to designing college courses*. John Wiley & Sons, 2013.

[24] L. Abeysekera and P. Dawson, "Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research," *High. Educ. Res. Dev.*, vol. 34, no. 1, pp. 1–14, Jan. 2015.

[25] J. Cohen, *Statistical power analysis for the behavioral sciences*. 2013.

[26] G. M. Sullivan and R. Feinn, "Using Effect Size—or Why the *P* Value Is Not Enough," *J. Grad. Med. Educ.*, vol. 4, no. 3, pp. 279–282, Sep. 2012.

[27] D. Lakens, "Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs," *Front. Psychol.*, vol. 4, 2013.

[28] M. Norusis, *SPSS 14.0 Statistical Procedures Companion*. Upper Saddle River, NJ: Prentice Hall, 2005.

[29] R. M. Clark *et al.*, “Flipping Engineering Courses: A School Wide Initiative.,” *Adv. Eng. Educ.*, vol. 5, no. 3, 2016.

[30] A. Dallal and R. M. Clark, “Progressive Use of Active Learning in Electrical Engineering Courses,” in *ASEE Annual Conference & Exposition*, 2019.

[31] N. A. Bradbury, “Attention span during lectures: 8 seconds, 10 minutes, or more?,” *Adv. Physiol. Educ.*, vol. 40, no. 4, pp. 509–513, 2016.