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Thea BJØRNLAND
Department of Mathematical Sciences, Norwegian University of Science and Technology, Norway,
thea.bjornland@ntnu.no

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DIGITAL LEARNING RESOURCES, HYBRID TEACHING AND REMOTE STUDENTS - ARE OUR STUDENTS ACTIVELY ENGAGED?

T Bjørnland [1]
Department of Mathematical Sciences,
Norwegian University of Science and Technology
Trondheim, Norway
ORCID: 0000-0003-1054-5410

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ABSTRACT

At the Norwegian University of Science and Technology, a new cross-campus statistics course for approximately 1000 engineering students was planned for the fall of 2020. Due to the pandemic, digital learning resources were developed to allow students to work from home or campus, individually or collaboratively. These resources include short learning videos, automatically graded exercise sets, and Jupyter Notebooks for Python coding. Since 2020, digital learning resources have been essential for teaching statistics to engineering students across three campuses, and remotely. To help students navigate digital resources, on-campus activities, and assessments, each week of the semester was structured according to specific learning paths. However, asking the students to watch videos and work on exercises before on-campus or digital lectures is no guarantee that they will do so. For this study, we use video and assessment statistics, along with survey results, to determine to what extent the proposed learning paths were followed and the

[1] *Corresponding Author*
T. Bjørnland
thea.bjornland@ntnu.no

perceived usefulness of the various elements that make up a learning path. In surveys, the engineering students at the Norwegian University of Science and Technology report great satisfaction with videos and digital assignments (along with scaffolding exercises) in the statistics course. By utilising digital user statistics, we observe patterns of engagement with digital resources that are closely tied to the proposed learning paths.

1 INTRODUCTION

1.1 Background: A new statistics course in the middle of a pandemic

In 2016, the Norwegian University of Science and Technology (NTNU) merged with three Norwegian colleges. Therefore, NTNU now offers bachelor engineering programs in three different counties, with many basic courses running in parallel across three campuses. The statistics group at the Department of Mathematical Sciences has since 2020 been offering the mandatory third semester undergraduate statistics course (7.5 ECTs). This course covers well-known topics such as probability and probability distributions, reliability, descriptive statistics, and basic statistical inference. In addition, the students complete one module relevant for engineering applications; design of experiments and statistical process control; measurement error and error propagation; or data science and statistical learning. Approximately 1000 engineering students from 12 different study programs enrol in this course annually (some programs also offering remote studies).

In the fall of 2020, a new team of lectures located across the three campuses were to develop and teach this cross-campus statistics course for engineers for the first time. Due to the ongoing pandemic and social restrictions, we had to plan for a completely digital off-campus learning environment. Geographical and multicampus challenges then being erased, the team decided to avoid giving parallel digital 'local' lectures. Instead, we could take on different development tasks; developing short learning videos (5-15 min) as a way of introducing new material to the students; giving a complementary digital session with worked examples; developing weekly digital quizzes; and preparing material for the various project modules. Despite a challenging and hectic semester, we were left with the overall impression that we had developed a resource bank and a way of coordinating teaching that could benefit both the students and us. Since then, we have built a blended learning environment for hybrid cross-campus (and remote) teaching. We *intend* our students to watch learning videos at the beginning of the week (especially before they attend the mid-week campus-based lectures), and we *suggest* that they start working on the weekly assignments early so that they manage to finish in time for the Friday evening deadline. Now we ask ourselves, are our students actively engaged?

1.2 Motivation: Blended learning

The motivation behind this paper is twofold. First, we present a post-covid blended learning environment in statistics for engineering students. As a definition of blended learning, we adopt the following definition of Boelens et al. (2015): "…*learning that*

happens in an instructional context which is characterized by a deliberate combination of online and classroom-based interventions to instigate and support learning". A shift from mainly classroom-based instruction to digital resources can foster students' control of their own education in terms of mode and pace of learning (Castro 2019). Furthermore, differentiated modes of instruction and learning materials can be valuable for heterogeneous student groups (Boelens et al. 2018), also in terms of living circumstances (Guppy 2021). In an engineering mathematics course, Liestøl (2020) found that students often waited until the last day before assignments to watch videos and skipping videos considered less important or too lengthy. As students may show up unprepared for in-class sessions if the required pre-class workload is too high the length of learning videos is typically recommended to be 6-9 minutes (Guo et al. 2014) or 12-20 minutes (Lagerstrom et al. 2015). For this study, we will compare data from the two 'post-covid' semesters fall 2021 and fall 2022, focusing on the engagement (both overall use and time of use) with learning videos and digital assignments. Our aim is to gain insight into students' engagement with digital resources.

2 THE COURSE

2.1 Course content and structure

This paper concerns students' engagement with digital learning resources during the first nine weeks of the statistics course for engineers at NTNU. This part of the course is assessed with an individual digital exam that counts towards 70% of the final grade (the remaining 30% of the grade is based on a group project in one of three optional modules). Each week is defined by a specific topic: 1. Descriptive statistics; 2. Probability of events; 3. Stochastic variables; 4. The binomial distribution; 5. Poisson processes and reliability; 6. The normal distribution; 7. Estimation and confidence intervals; 8. Hypothesis testing; 9. Simple linear regression. For each topic (and therefore each week) we have developed 3-4 short learning videos; a catalogue of in-depth examples for campus-based sessions; Jupyter Notebooks with worked data examples in Python; and digital assignments. The students are required to pass (i.e., at least 8 out of 10 points) at least 6 of these weekly assignments, while all other activities during these first nine weeks are voluntary. We offer both on-line and on-campus tutoring each week. The digital exam questions are of a similar type as the quizzes, but without access to other tools than calculators and formula sheets.

2.2 Weekly learning paths

For each topic (and week) we present the students with a recommended learning path, see Figure 1 for a generic representation. We recommend that the students watch the learning videos and attend the 45 min digital cross-campus plenary overview lecture in the beginning of the week, and especially before attending the mid-week campus lecture. The campus lecturer organises this session based on the assumption that the students have watched the videos. The deadline for the weekly assignments is at the end of the week, but we recommend that the students start out

early (the first few exercises are always at an introductory ‘get-started’ level). All materials and information necessary to complete a topic become available to our students in our ELS (Blackboard) on the Friday prior to week in question.

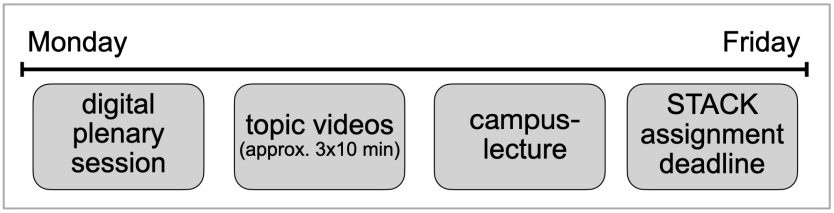

Figure 1. Weekly learning path

2.3 Learning videos, Jupyter Notebooks and assignments in STACK

Our learning videos are hosted in Panopto, one folder for each week, three or four videos per topic. The videos are based on animated Keynote presentations where the lecturer introduces the main concepts of the topic. The length of each video is between 5 and 15 minutes. Python is the preferred programming language for the engineering programs at NTNU, and therefore also used for data analysis and computations in the statistics course. Any data analysis presented in a video may be reproduced by our students by interacting with the corresponding Jupyter Notebook. Notebooks for generic calculations with probability distributions are also available to them. Each week, the students are also given a digital assignment created with the STACK question type in Moodle. For each question, all students get a similar statistical problem to solve, but the numbers (and therefore also the answers) are random and individual. We encourage collaboration on methods, but each student must submit his or her individual calculation. We have also developed corresponding step-by-step scaffolding exercises in STACK so that the students may check intermediate calculations and get tips on how to proceed. Some of the weekly exercises guide the students to a Jupyter Notebook where they must edit and run code and report an output back into the STACK-assignment.

2.4 A (subtle) change between two semesters

For historical reasons, we started teaching this course with a one-week delayed deadline for assignments. The learning path presented in Figure 1 was promoted by lecturers in 2021, but the actual assignment deadline was in fact one week later. During that semester, local lecturers observed that students tended to be behind with their work, so that the weekly campus lecture made no sense to them. For 2022 it was therefore decided to give the students a much tighter deadline (see Figure 1).

3 METHODOLOGY

For this study, we use anonymous video and assignment statistics to determine to what extent the proposed learning paths were followed in 2021 and 2022. We also present anonymous survey results regarding the perceived usefulness of the various elements that make up a learning path. Video statistics were downloaded from the platform Panopto where the videos are hosted. We used the count of all viewings of

length greater than four minutes as an estimate of the number of students watching a certain video. Averages were taken over the number of videos for each week (3 or 4). The exam period was not considered. For the assignments in STACK we report the weekly number of attempts as well as the start day of these attempts. In both 2021 and 2022 an anonymous survey was sent to all students, the response rate being approximately 22% in 2021 and 32% in 2022. In both surveys, students' perceived learning outcomes from various learning resources were reported. The results of the data analysis are presented in Section 4, while a discussion of our findings is given in Section 5. Data visualisation was performed using ggridges (Wilke, 2022) for ggplot2 (Wickham, 2016) in R (R Core Team, 2022).

4 RESULTS

4.1 Assignments in STACK

In Table 1 we present the number of attempts for the weekly assignments. The number of attempts for the first assignment is taken as an estimate of the number of students following the course. In both 2021 and 2022, the number of attempts was above 90% throughout the first six weeks, before it dropped to nearly 60% for the ninth topic. The required test score was 8 out of 10, and in terms of average scores we observe a decline towards last weeks, but no notable differences between the two years.

Table 1. The number of attempts per exercise set (assignment) in STACK (exam period excluded) as well as the average total score (out of maximum 10) and corresponding standard deviation (SD). Percentages are based on the number of views relative to the estimated number of active students (1147 in 2021, 1076 in 2022).

Topic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2021	1147 (100%)	1106 (96%)	1094 (95%)	1098 (96%)	1102 (96%)	1077 (94%)	975 (83%)	863 (75%)	704 (61%)
Score (SD)	8.9 (1.9)	8.9 (1.7)	8.7 (1.7)	8.9 (2.0)	8.5 (2.2)	8.2 (2.1)	7.9 (2.8)	7.5 (3.4)	7.4 (3.4)
2022	1076 (100%)	1056 (98%)	1044 (97%)	1037 (96%)	1022 (95%)	999 (93%)	931 (87%)	798 (74%)	677 (63%)
Score (SD)	9.0 (1.4)	8.6 (2.0)	8.6 (1.7)	8.8 (2.1)	8.6 (1.9)	8.3 (1.8)	7.9 (2.7)	7.2 (3.3)	7.6 (3.1)

In Figure 2 we present frequencies of starting dates for the weekly assignments. Here, we observe a substantial difference in student behaviour between the two semesters. In 2022 most students started the assignment on Mondays. In 2021 however, we observe two 'modes' of student behaviour. Approximately half (or even less) of the students started working on the assignments in the intended week (uniformly spread out between Monday and Friday), while the other half postponed the exercise set until the following week, i.e., the week of the deadline.

In 2022 there are two additional observations to be made. Prior to week 7 and 8, some students reached out to us regarding taking an autumn break (in line with the

Norwegian school holidays) and requested learning materials to be published one week prior to the schedule. The work of these students can be seen as an early peak in weeks 7 and 8. Furthermore, because some students have side-jobs during the week, they requested the deadline to be moved from Friday to Sunday so that they could use Sundays to catch up on their studies. This delay can be seen in Figure 2 (2022) for weeks 8 and 9.

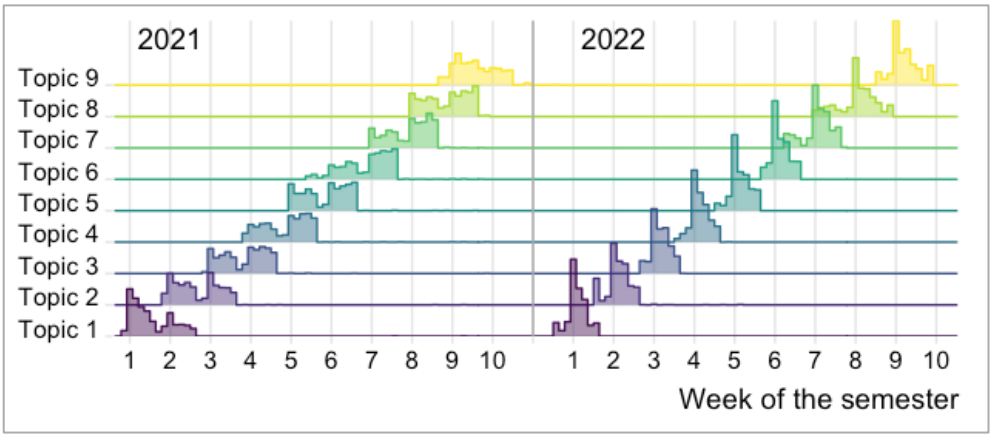

Figure 2. Frequencies of starting dates for weekly STACK assignments in 2021 and 2022, comparing starting dates per topic between the two semesters. Monday is the first day of each week (grey vertical lines). In 2021, exercises were made available the Friday before the topic was covered and the deadline was Friday two weeks later. In 2022, exercises were similarly made available the Friday before and the deadline was Friday one week later.

4.2 Learning videos

Video view counts per topic (1-9) are presented in Table 2. By assuming that few students watched substantial proportions of each video more than once (not counting the exam period) and that few students watched videos in groups, these numbers can be taken as estimates of the number of students engaging with this digital resource. We observe that between 70% and 80% of students watched learning videos each week, but with a drop in view counts towards the end which follows the same trend as for the assignments (Table 1).

Table 2. The average number of views (at least 4 minutes) per video for each topic in the fall semesters of 2021 and 2022 (exam period excluded). Percentages are based on the number of views relative to the estimated number of active students (1147 in 2021, 1076 in 2022).

Topic	1	2	3	4	5	6	7	8	9
2021	1043 (91%)	978 (85%)	1015 (89%)	860 (75%)	827 (72%)	884 (77%)	782 (68%)	901 (79%)	788 (69%)
2022	813 (76%)	917 (85%)	843 (78%)	841 (78%)	780 (73%)	797 (74%)	750 (70%)	796 (74%)	557 (52%)

In Figure 3 we present frequencies of video viewings for the nine topics, comparing each topic between the semesters of 2021 and 2022. We see a trend that is very similar to that of the assignments (Figure 2). In 2022 most students watched videos

on Mondays (thereafter Tuesday and Wednesday), while in 2021 we again observe two ‘modes’ of student behaviour; approximately half of the students followed the intended schedule, while the other half was delayed by one week.

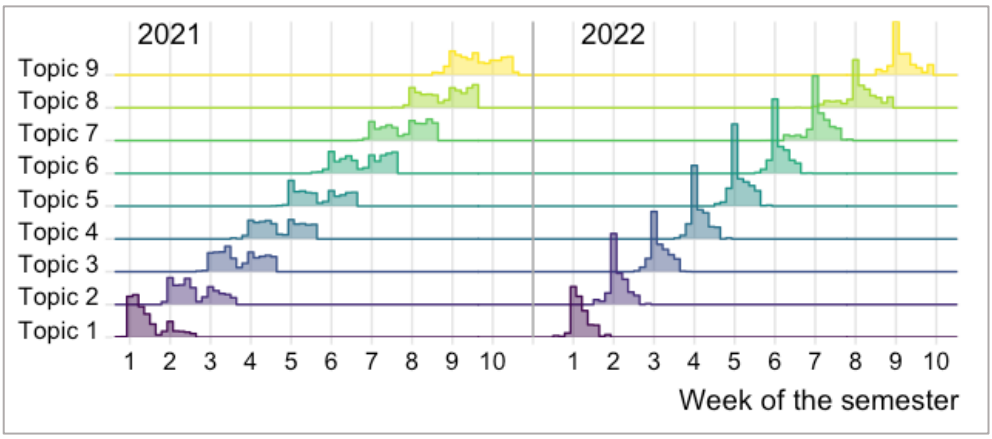

Figure 3. Frequencies of video viewings in 2021 and 2022, comparing dates per topic between the two semesters. Monday is the first day of each week (grey vertical lines).

4.3 Survey results

In 2021, students were asked to select the top four (out of thirteen) learning resources for their (perceived) learning outcome. Out of 251 respondents, 89.2% selected the STACK assignments, 74.1% selected the learning videos, 54.2% selected previous exam questions, and 52.2% selected the STACK step-by-step scaffolding exercises. Only 8% of respondents rated the Jupyter Notebooks top four. The digital plenary lectures, campus lectures and textbook were selected among top four resources by 14.3%, 12.7% and 14.3% of respondents, respectively.

In 2022, students were asked to evaluate their perceived learning outcome of each resource individually. For the digital STACK assignments, 82.3% of respondents reported a good or very good learning outcome and for the learning videos, 76.2% of respondents reported a good or very good learning outcome. The corresponding results were 76.5% for digital scaffolding exercises, 42.4% for previous exam questions, 35.5% for Jupyter Notebooks, 33.8% for the digital plenary lecture, 48.0% for the campus lecture, and 28.1% for the textbook.

5 DISCUSSION

In this paper we have presented a method of blended teaching in a statistics course for engineers. In this course we propose a learning path that students may use to navigate various digital recourses and on-campus activities. The deadlines for the mandatory element of the course (weekly quizzes) are set by us, and as seen in this paper the deadline has a clear impact on the overall pace of studies. However, by using short topic videos as the main ‘lecturing’ format, we have shifted the control of timing and pace of lectures from the lecturer to the student.

When we in 2021 gave the students a late deadline (one week after the topic was ‘lectured’), about half of the students were delayed both when it came to starting the

assignments and watching the videos. As the videos were intended to be viewed prior to the mid-week campus-lecture, the delayed students were likely either skipping all lectures or having a poor learning outcome if attending. This delay in student behaviour also led one of the campus-lecturers to change the format of the session; instead of covering examples that should expand the week's curriculum, the lecturer had to introduce the curriculum. Based on statistics from 2022, we see that a stricter deadline for the assignments coincides with the students engaging with the digital resources in line with the suggested learning paths. The proportion of students doing the assignments and using the short topic videos as a learning resource was however similar between these two years.

Although we have no official statistics, we would guess that by the end of the first nine weeks, about 30% of the students attended digital and campus-based sessions. Clearly, far more students watched videos than attended lectures and one can of course speculate whether attendance would improve if less material was covered by the videos. From survey results we also see that the students rate the videos as far more important for learning than the lectures. This is somewhat unsurprising given the attendance rates, and when keeping in mind that the videos introduce new theory which the campus sessions build upon and extends.

Our results must also be viewed in the relevant context; both due to the pandemic and the cross-campus nature of the engineering programs at NTNU, our students are used to – and expect – a digital or hybrid learning environment in basic courses. For us, the use of learning videos instead of solely campus-based lectures ensures fairness and equal opportunities across campuses. It should be noted that the efforts made by the team of lecturers to produce all learning materials in 2020 (and thereafter improving and updating) have been substantial. However, we have tried to make a course where we minimize the amount of work being done in parallel across campuses and distributed various development tasks among the team of lecturers.

In this study we have focused on students' use of digital learning resources, revealing different strategies chosen among students in two semesters with the same blended learning environment. We find that with sufficient guidance - which includes both learning paths *and* appropriate deadlines - to the navigation of learning resources, the engineering students successfully engage with digital learning resources for learning statistics. Of note, our top-rated learning resources were developed according to current advice; short learning videos (5-15 min) and exercises with immediate feedback (formative assessment) complemented by step-by-step help exercises (scaffolding). For further work, we are focusing on improving the integration of Python programming, and on the end-of-term team-based engineering projects.

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