Experiences using video technologies in teaching programming

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Abstract

This paper deals with experiences of the author and other staff at UiS in using recorded lectures and other video technologies in teaching. Fewer students show up for the lectures than they used to before recording and streaming was introduced, which means that the teacher has much less contact with the students. The videos are used by students who cannot or do not want to attend the regular lectures. The videos are also used for repetition and checking things that students struggle with. Only a few students watch whole recorded lectures, the majority just watch smaller parts of them. Recorded lectures are popular with the students. There appears to be little difference in student performance as measured in exam results before and after recorded lectures was introduced.

1 Introduction

Today there is an increased focus on using alternative forms of teaching instead of or in addition to regular lectures. The equipment for recording and streaming lectures is becoming more available. Students are asking for video streaming and other forms of teaching that are different from the regular lectures. Introductory programming courses often have high failure rates both at UiS and at other universities [1], [2]. The author has therefore started using video in the teaching of a freshman course in basic object-oriented programming using Java.

The paper mainly looks at the freshman course "Object-oriented programming", which has the code DAT100. The course has roughly 150 students. The course is taken by students in Computer Science and Electrical Engineering. The course is held during the spring. The course is a basic course in Java programming and the students taking it have had a brief introduction to programming in MATLAB in a course the previous semester. In addition to lectures, the course has 10 programming exercises, 9 of which need to be approved in order for the student to be allowed to take the exam. These exercises are spread throughout the semester.

This paper looks at how students use two different forms of on-line video to supplement ordinary lectures. The first form is called microlectures in this paper. A microlecture is roughly 10 minutes long. The microlectures are pre-recorded. They were made as scripted screencasts where the teacher explains a concept while showing either powerpoint slides or an actual programming environment (Eclipse, www.eclipse.org).

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Some examples were programmed during the microlecture. The microlectures were primarily motivated by the students struggling with some of the topics in object-oriented programming, and on-line platforms like Khan Academy have had success with the format. The microlectures are posted on Youtube (www.youtube.com) on the account of the University of Stavanger. They are publicly available and do not require login.

The other form of video is regular lectures that are both streamed live and recorded so that they can be viewed later. These are recordings of ordinary two times 45 minutes lectures, complete with breaks, student questions and the occasional technical error. The recordings were started because the students asked for them, the equipment to record them was available and the teacher had no problem with it. The recorded lectures are posted on the Mediasite (http://www.sonicfoundry.com/) server of the University of Stavanger. The Mediasite server requires the users to log in with their UiS accounts in order to view the recorded lectures.

2   Related Work

There is some literature on the use of microlectures. The papers [3] and [4] deal with using the inverted classroom technique to teach programming, including using podcasts that resemble the microlectures from the current work. They generally find a small improvement from using flipped over traditional teaching methods.

The paper [5] describes some of the benefits and pitfalls of using streamed video. Benefits include the ability of students to watch the lecture at their own pace and possibly watch part of it several times. Another advantage that applies to microlectures is splitting the curriculum into more easily digested chunks, and the ability to update the video at one place and have the alteration be visible to all. Some of the drawbacks described in the paper are of a technical nature and are less relevant now. One that is still relevant is the fact that students passively watch rather than being actively involved. However, this is also a problem of traditional lectures. A similar study has been done in another course at our university [6], in Norwegian. In [6], a small but significant improvement in learning was noticed for those topics for which microlectures were provided.

In [7], they have used recordings of regular lectures in several courses in two universities in the Netherlands, and have then conducted a survey among the students in order to find how and how much the students used the recorded lectures. Their main results are that the students use the lectures as replacements for missed lectures and for preparing for the exam. Additionally, their students report watching all or almost all of the lecure when they view one. As described later in this paper, this is different from the result in the current study. In [8], the same authors have done a data analysis of the log files of the software for displaying the recorded lectures. They give far less detail than in this paper, but the trend seems to be more similar to what I have experienced.

In [9], a geology class was divided into two parts, one of which had webcasts, similar to the streamed lectures in this paper, and one without. Results were slightly better in the webcast group but attendance in the lectures was significantly lower. A similar study would be infeasible for computer science students as the non-webcast group could get access through friends in the other group.

3   Effects of using video for teaching

The main effects are outlined in this section. One important effect is a reduced attendance in the lecture hall. The results further on in this paper show that many students use the videos. However, the results on the exams have not been significantly altered by using videos.

3.1 Reduced attendance in the lecture hall

The attendance in the lectures is significantly reduced. Towards the end of DAT100 the attendance was around 15%, as opposed to 35% in the year before streaming was introduced. During the later parts of the spring semester of 2016, there were more students attending my lectures in DAT220 database systems than my lectures in DAT100. DAT220 did not use video for teaching and had roughly 50 students. DAT100 used recorded lectures and had roughly 150 students.

Other teachers report the same effect:
- Tom Ryen, teaching ING100 Introduction to Engineering for roughly 500 students
- Jan Terje Kvaløy, teaching STA100 Statistics for roughly 500 students
- Anders Tranberg, teaching FYS100 Physics for roughly 500 students

The low attendance may be a problem in some courses. The students need to be pushed into working evenly through the semester, and requiring them to attend regular lectures may do this. If the students can view the lectures when they please, they may try to do so immediately before an exercise deadline or immediately before the exam. As the lectures take time to view, this is not a feasible strategy. This has been a greater problem in STA100, which has only a few exercises, than it has been for DAT100, which has more exercises and where the exercises force the students to work evenly throughout the semester.

3.2 Many students use the videos

Both the microlectures and the streamed lectures are used quite a lot. See section 4 for microlectures and section 5 for streamed lectures. Students the author has talked to say that they watch the streamed lectures speeded up by x1.4 or even x2.

3.3 Effects on exam results

There is a small improvement in exam results compared to previous years, but not enough that the author would deem it significant. This improvement may also be due to other factors such as the exam being easier or the students being slightly better. Jan Terje Kvaløy reports similar experiences in his course.

3.4 Vulnerability to technical difficulties

On problem with using recorded lectures is that the course becomes more vulnerable to technical difficulties. An ordinary lecture in DAT100 would be vulnerable to a failure in the computer used for lecturing as well as a failure in the projector used to display the computer screen for the students to see. When recording the lecture, it is additionally vulnerable to a failure in the recording systems and a failure in the Mediasite server. For the spring of 2016, only the first 6 out of 28 lectures were streamed live, the rest were only recorded for viewing afterward, and in the 6th lecture the streaming was interrupted 2/3 of the way through. This was due to technical difficulties. These issues were resolved so that the lectures of 2017 have been both streamed and recorded with little difficulty.

4 How the students use microlectures

The microlectures are on Youtube, and one can find a fair amount of statistical information on youtube for the videos that one has uploaded. The table below is based on statistics from 2016 and 2015. The microlectures 6 to 9 were made during the autumn of 2015 and were not available during the course in 2015. The course is held during the spring. The course has roughly 150 students each year. Note that only part of the

curriculum was covered with microlectures. Early topics such as control structures and methods are covered by similar microlectures in an earlier course (ING100). Later topics are not covered yet.

Table 1: Number of microlecture viewing sessions

Title	Views 2016	Views 2015	Comments
1: Introduction to classes and objects	452	371	Link from NTNU
2: References	209	226	
3: How to make your own classes	270	240	Link from NTNU
4: Encapsulation	353	181	Link from NTNU
5: References, part two	202	159	
6: Inheritance	208		
7: Polymorphic method calls	186		
8: Abstract classes	186		
9: Interfaces	287		

The difference between "references" and "references, part two" is that the first deals with what a reference is and how this affects how parameters are passed to methods. The second deals with composition, objects that contain other objects.

The number of views has a generally sinking trend with some exceptions. The microlecture "Interfaces" is more popular than the ones before, most likely because the topic Graphical user interfaces makes heavy use of interfaces.

Three of the microlectures were linked to from the wiki pages of a similar course held at NTNU. Youtube can only filter the viewers by country (using their IP address). It is therefore impossible to separate UiS from NTNU users.

4.1 When during the semester the microlectures are used

In order to understand when the microlectures were used by the students, graphs showing views per day were fetched for all the microlectures. There were three viewing peaks for most of the microlectures, with few views outside the peaks:

1. The first week after they are posted. They are posted right after the topic was covered in regular lectures.
2. The last week before the exercise deadline of the exercise covering that part of the curriculum.
3. The last week before the exam

Figure 1, Figure 2 and Figure 3 show statistics for some example microlectures, including annotations showing what happened in the teaching of the course during each peak.

Lecture on the topic, microlecture posted January 15

Next lecture on the topic January 21

Relevant exercise deadline February 3.

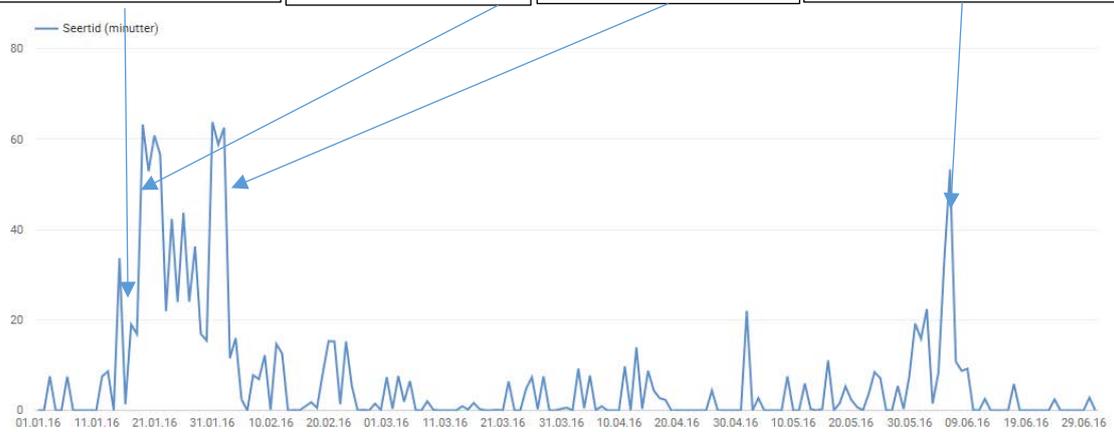June 6, the last day before the exam on June 7.

Figure 1: Views per day for microlecture 1

February 8, next workday after the lecture Friday February 5.

Exercise delivery deadline March 2

June 6, the last day before the exam on June 7.
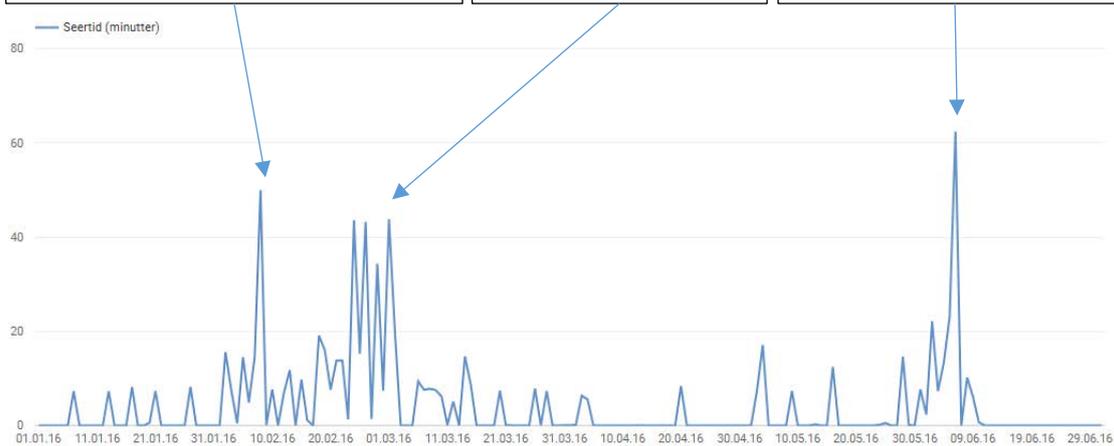
Figure 2: Views per day for microlecture 6

Video posted February 18

Topic lecture February 21

Exercise delivery deadline March 16

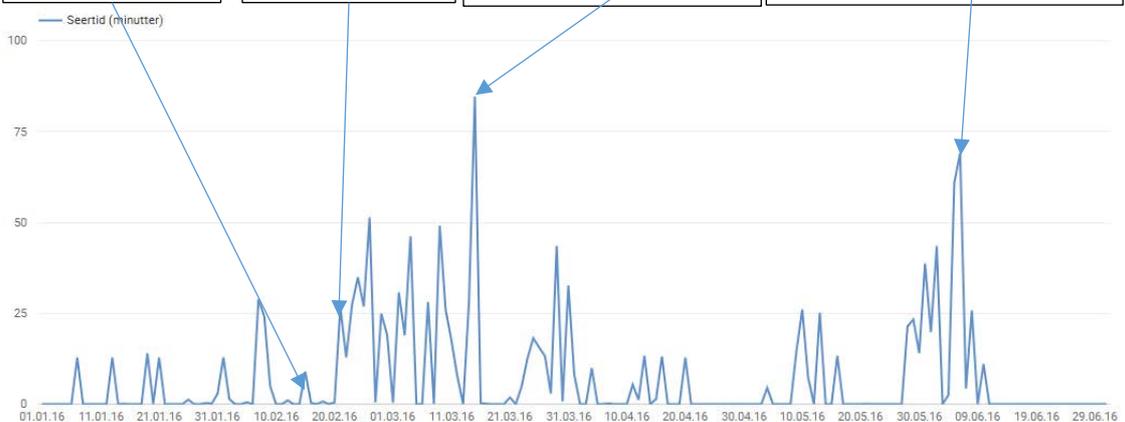June 6, the last day before the exam on June 7.

Figure 3: Views per day for microlecture 9

4.2 Which parts and how much of the microlecture is watched

In order to understand how much of the microlecture the students watch and which parts they watch, curves for how many users watched which sections of each microlecture were fetched. Figure 4 shows the number of views per time unit for microlecture one. The vertical axis is the percent of users who have watched this part of the lecture. In order to be counted, a user must have watched at least some part of the lecture. The horizontal axis shows time in minutes and seconds from the start of the microlecture. The number of views per time unit of the other microlectures are similar, except for videos three and six.

Figure 4: Percent of users viewing each part of microlecture 1

Figure 5 shows the number of views for microlecture 3 (how to make your own classes). Annotations showing what occurs in each part is included here because the viewing pattern was much less even than for the others, and also differed from what Tom Ryen found in [6].

The microlecture 6 (inheritance) shows a similar pattern to this lecture. It lies around 60% views for the entirety of the theory section in the beginning, rising to 90% when it shows how to write a subclass based on an already known base class, and then sinking gradually to 50% at the end.

5 How the students use streamed lectures

This section contains statistics for some selected streamed lectures. This is extracted from a large Excel sheet with statistics from all the streamed lectures. Figure 6 shows number of views for all the streamed lectures in the spring of 2016. After an analysis of Figure 6 there are sections analyzing three individual streamed lectures chosen because they are in different parts of the semester and show different viewing patterns.
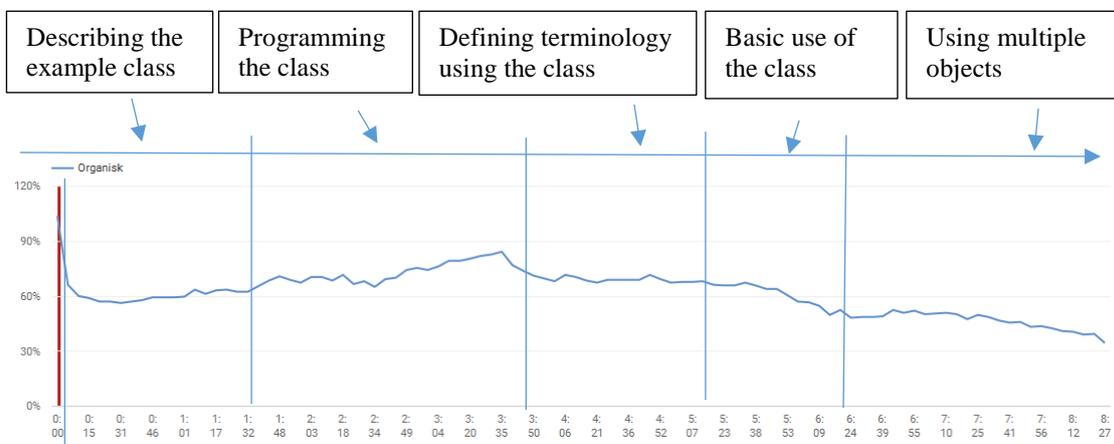

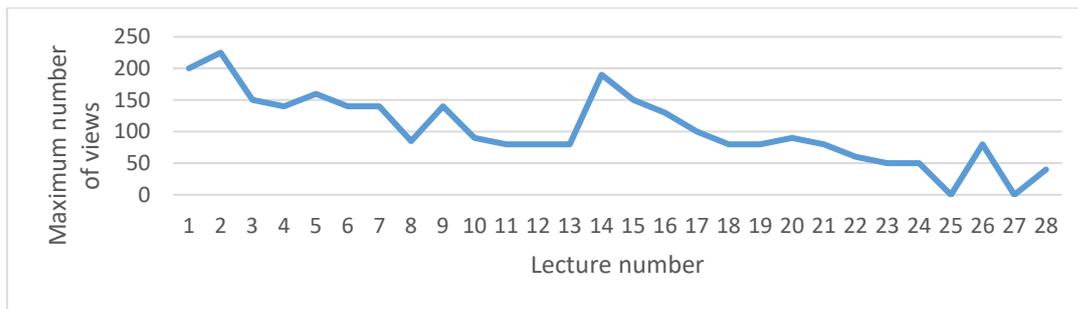*Figure 5: Percent of users viewing each part of microlecture 3*

Figure 6: Number of users viewing each streamed lecture, spring 2016

There is a general sinking trend, as students seem to drop off during the course. The exceptions to the sinking trend are lecture 8, which has fewer views than those after it, and lecture 14, which has many more views than the ones before it. Lecture 8 was presentation of exercise five and presentation of the solution to exercise three. This shows that presenting new concepts might be more popular than presenting solutions to exercises. However, lecture 26, presenting the solution to exercise nine, was more popular than lecture 23, the last lecture presenting new topics. Lecture 25 and 27 were cancelled and therefore have no views.

Lecture 14 was the start of the topic "Graphical user interfaces", which is clearly more popular than the preceding topics. The author's experience is that many students understand the concepts in the preceding lectures (inheritance, polymorphism, interfaces) only when they get to program graphical user interfaces.

In the remainder of this section, detailed viewing history for three streamed lectures is given. They were chosen because they are in different parts of the course and have different viewing history. For each of the three lectures, two figures are shown:

1. Views per time unit. This shows which parts of the streamed lecture the students have watched. It corresponds to Figure 4 and Figure 5 for the microlectures.
2. When during the semester the students watched the streamed lecture. This corresponds to Figure 3 for the microlectures and is used along with item 1 in this list to compare the usage patterns of the microlectures and the streamed lectures.

Additionally, two figures are shown comparing the viewing patterns of all three streamed lectures:

1. Number and duration of each viewing sessions. From the first figure set, it was clear that the students do not view the whole lecture, so it might be interesting to see how long the typical viewing session was.
2. How much each user watched in total. As the number of viewing sessions was much larger than the number of users who had watched the streamed lecture, it was clear that many users watched the streamed lecture in sections. Thus it might be interesting to compare the length of viewing sessions with the length of time the students watched in total.

5.1 Lecture 2, Friday January 8

This lecture was the most viewed lecture in the entire course. It was viewed 487 times in total by 130 different users. It was the second lecture in the course.

Figure 7 shows the number of views during the lecture as well as annotations describing the contents of the different sections of the lecture. It clearly shows that the students do not view the entire lecture but that they fast-forward to the bits that interest them. In this lecture, the most interesting bit was the bit where the lecture showed how to

read text from the keyboard so that programs could take input from the users. The 15-minute break between the two 45-minute lectures is very predictable and the students fast-forwarded over it.

Figure 13 shows both that many views are of short duration and that a number of views are pure mis-clicks. All the views shorter than 15 seconds and many of those shorter than one minutes are most likely mis-clicks as you don't get much from watching just 15 seconds. One cause for these mis-clicks is that the streamed lectures are labelled on Mediasite only by date and not by topic, so the students may have to try a couple of lectures before they find the one they are interested in. Note however that the microlectures also have a number of short views of just the beginning (see for instance Figure 4). For the microlectures, the students can see the title of the lecture before they start viewing it.

Figure 14 shows that there is a good range of views. Combined with Figure 13, it shows than many students viewed much of the lecture but not all in one session. Rather, the students appear to split their views over several shorter sessions.

Figure 8 shows that the lecture is mostly viewed in the week immediately after it was posted. The viewing peak at January 19 is one day ahead of the deadline for approving exercise 1. Unlike the microlectures, this streamed lecture is not used much for exam preparation. Note that Figure 8 does not contain views after the exam as the regular teaching stopped then. There were 11 views in July, 1 view in August and 6 views in December 2016.

5.2 Lecture 15, February 26, 2016

To contrast with the lecture on January 8, here is a later lecture, chosen because it had a very uneven number of views in the different parts of the lecture, as shown in Figure 9.

Figure 13 and Figure 14 show that in this lecture, the short duration of individual viewing sessions is clearer than for streamed lecture 2. Also, there is a peak in the number of users who have seen 30%-40% of the lecture. These students were interested in the new parts of the curriculum (GUI combined layout demonstration) but not in the exercise part.

Figure 10 shows that unlike the previous streamed lecture, this lecture was used for a much longer period. The peak on March 29 corresponds to the deadline for exercise 8. Like the previous streamed lecture, this one was not much used for exam preparation.

5.3 Lecture 20, March 17, 2016

This lecture is late in the course and was chosen because it had a very even number of views throughout the lecture, as shown in Figure 11. Almost the entire lecture is used to teach the students how to store and load text files. Exercise 9 is presented at the very end.

Figure 13 and Figure 14 also show how individual users used this lecture. From Figure 13 one can see that most of the viewing sessions lasted from 15 seconds to 40 minutes. In Figure 14 there is a large peak of users who have seen 80-90% of the lecture. As the break is 15 minutes out of 1 hour 45 minutes, or $1/7^{th}$ (14%) of the lecture, this means that most of the students who watched this lecture at all watched all of it, but in multiple sessions.

Figure 12 shows that the viewing dates for this streamed lecture has two clear peaks. The first peak was the day the lecture was held. The second is April 11 and April 12, the days before the deadline of exercise 9, April 13.
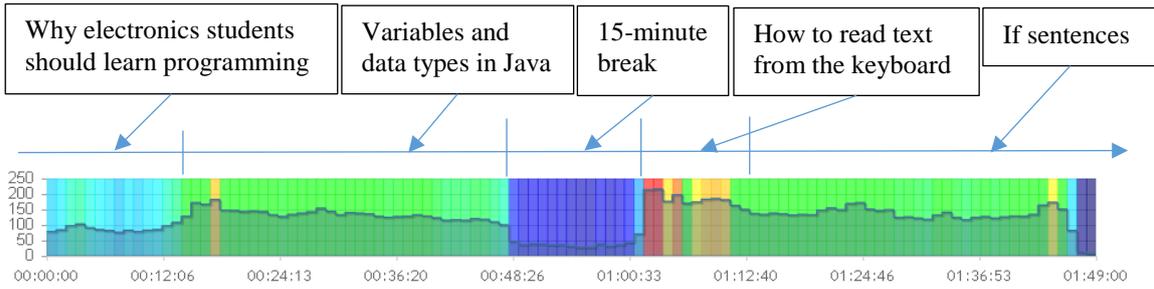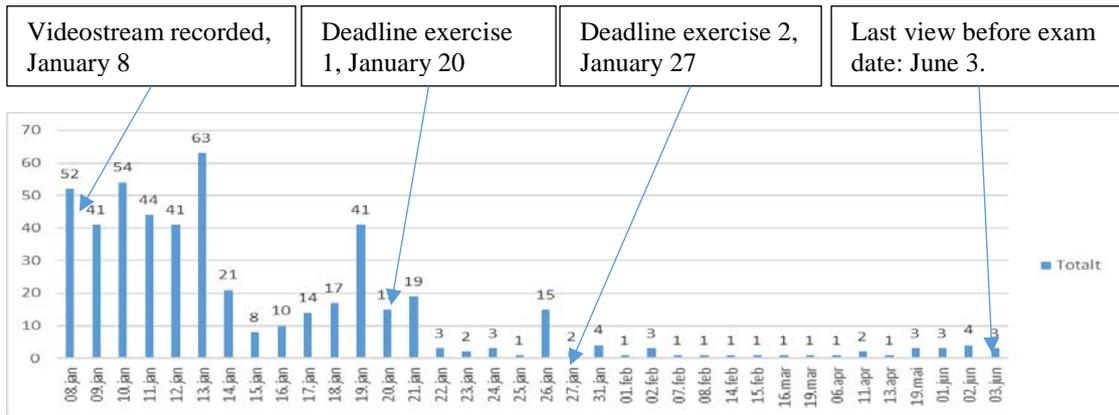
Figure 7: Views per time unit, streamed lecture 2

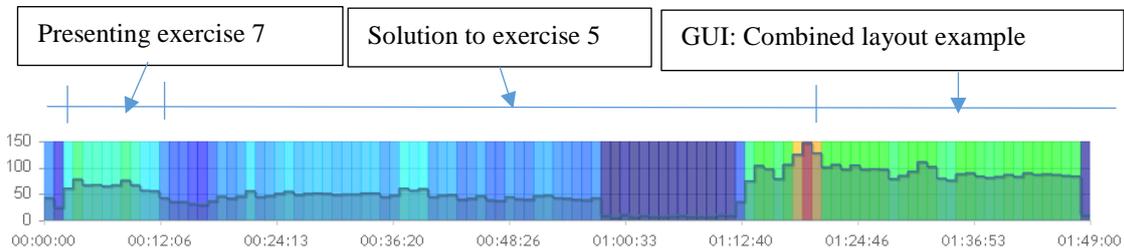*Figure 8: Views each day, streamed lecture 2*
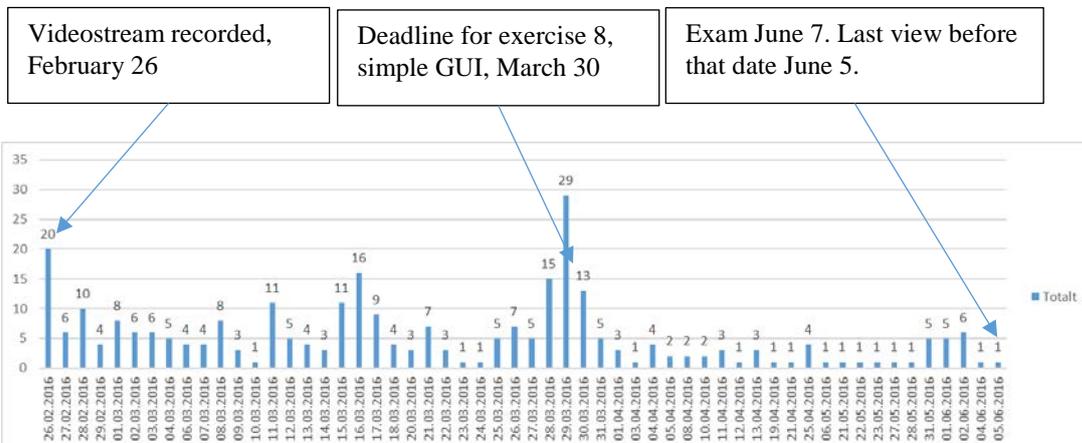

Figure 9: Views per time unit, streamed lecture 15

Figure 10: Views each day, streamed lecture 15
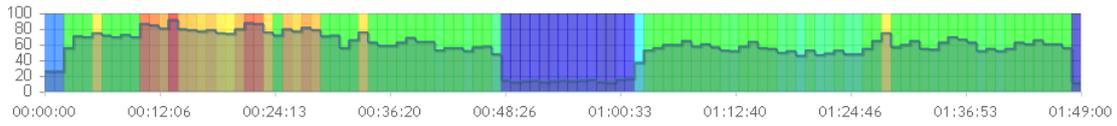
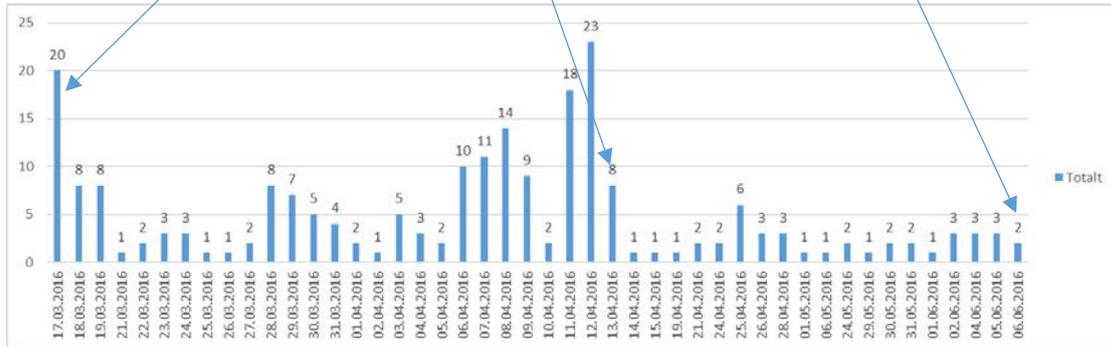*Figure 11: Views per time unit, streamed lecture 20*

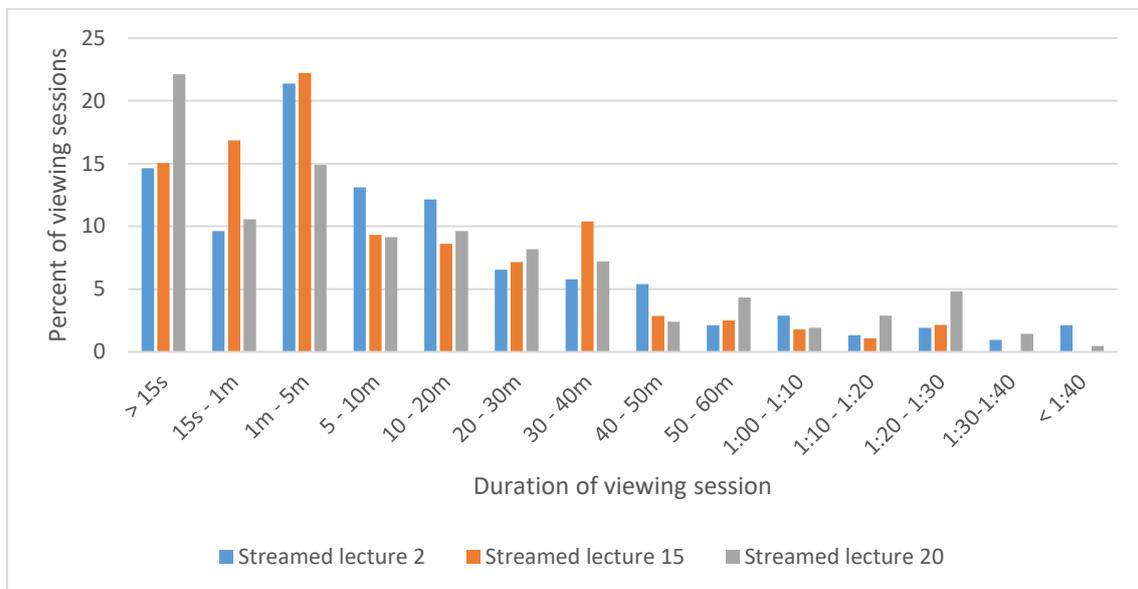*Figure 12: Views each day, streamed lecture 20*

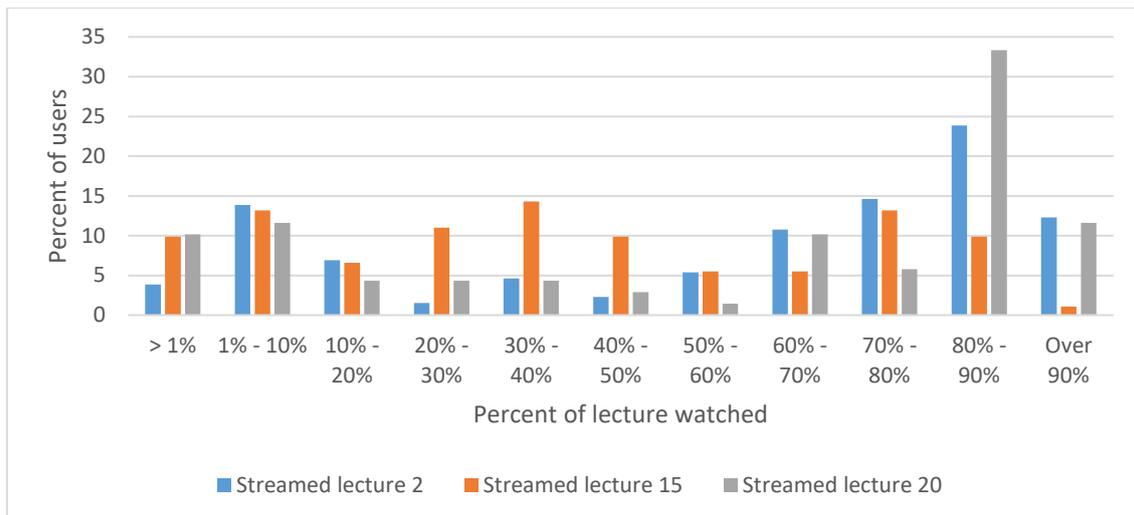*Figure 13: duration of individual viewing sessions*

Figure 14: How much each user watched in total

6 Conclusions and Summary

The number of views of the microlectures and the streamed lectures look similar. The numbers are all from 2016 so they are comparable:

- Microlecture 1: 452 views. Streamed lecture 2 has the most views with 482 viewing sessions. Microlecture 1 corresponds to streamed lecture 6, which has 365 viewing sessions.
- Microlecture 2: 209 views. This is also part of streamed lecture 6.
- Microlecture 3: 270 views. This is also part of streamed lecture 6.
- Microlecture 4: 353 views. This is also part of streamed lecture 6.
- Microlecture 5: 202 views. This is part of streamed lectures 6 and 8. Streamed lecture 8 has 234 viewing sessions.
- Microlecture 6: 208 views. This microlecture corresponds to streamed lecture 9, which has 254 viewing sessions.
- Microlecture 7: 186 views. This corresponds to streamed lecture 11, which has 207 viewing sessions
- Microlecture 8: 186 views. This corresponds to streamed lecture 12, which has 169 viewing sessions
- Microlecture 9: 287 views. This is also in streamed lecture 12.

This list uses viewing sessions rather than the number of students who viewed each lecture in order to make the numbers from Youtube and Mediasite as comparable as possible. The analysis of how much each user watched of the lecture in total is not available for the microlectures as this analysis requires the ability to recognize individual users. As the Youtube videos are public and do not require login, there is no ability to recognize individual users and thus no ability to see how much of the video that user has watched across several sessions. As the microlectures are much shorter than the streamed lectures and each microlecture contains one core idea, it is likely that far more of the users of the microlecture watched all or most of it compared to the streamed lectures. This means that Youtube cannot generate statistics similar to Figure 14.

The way the students use the two kinds of video lectures was different. For microlectures, those who are interested in the lectures watch them in their entirety. The large number of viewers in the beginning are most likely mis-click. For streamed lectures, many watch them in sessions consisting of just a few minutes each, often less than 10

minutes. However, a fair number of students have watched large parts of them over the course of many viewing sessions.

Many of the students use the microlectures for exam preparation, while few students use the streamed lectures for this purpose. Apart from this, the dates in which the two are used are similar: One peak right after the lecture on the topic is held, and another right before the deadline of the exercise on the topic.

7 References

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