Video production – mathematics for beginner students

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ABSTRACT[3]: Beginner student courses in mathematics in higher education have had high failure rates across the country. A national study [1] conducted by the Norwegian Association of Higher Education Institutions (UHR) in 2013 showed that students need help with the transition from upper secondary school to university or college.
As one of the initiatives following this study, UHR joined forces with Centre for Research, Innovation and Coordination of Mathematics Teaching (MatRIC) financing the production of mathematics videos that would help students with the transition from upper secondary school to university or college.
A group of six people from four higher education institutions, all with experience from teaching mathematics to upper secondary school students and/or first year university students, formed the video production group. So far the group has produced over 100 videos with a total running time of over 1000 minutes. These videos are freely available to everyone at the MatRIC TV web site [2] as a national resource.
The production group has made several decisions about the presentation of the mathematical material and the design of the videos along the way. In this contribution to the MNT conference we will discuss these choices and our experiences with producing these videos, and also their impact.

1 INTRODUCTION

In 2013 UHR conducted a national mathematics study where 2989 students and 80 teachers answered. The study aimed at strengthening mathematics and science didactics in STEM subjects by collecting information on how teaching and learning were practised at universities and colleges. The following quote (translated) from UHR's website gives one of the findings:

Work with better coherence between teaching and learning methods at the transition from upper secondary school to university and college is necessary.

Following this study a decision was made to start a project to produce videos covering the mathematical curriculum of upper secondary school, and present the mathematics as it is usually presented at university level.

This video project focused on producing mathematics videos, and it was not designed as a research project. Today many mathematics videos are produced all over the world. With this paper we want to share our experiences with producing mathematics videos and hope this might inspire and help others.

2 METHODS AND REFLECTIONS

The videos produced so far cover most of the curriculum of upper secondary school, in particular the following topics:

1. Basic set theory and algebra
2. Mathematical proofs
3. Powers and logarithms
4. Sequences and series
5. Planar coordinate system
6. Geometry
7. Trigonometry
8. Two dimensional vectors

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9. Functions
10. Differentiation
11. Integration

Special attention was given to topics that we experience students struggle with and topics we feel need a different presentation in higher education than is given in school mathematics.

2.1 Video production

So far six people have accepted the invitation to join the video production group. They come from four higher education institutions, and they all have experience from teaching upper secondary school students and/or first year university students. A majority of the group members had produced mathematics videos prior to participating in this group. The six people are:

- Tom Lindstrøm, University of Oslo (UiO)
- Anette Wrålsen, Norwegian University of Science and Technology (NTNU)
- Halvard Fausk, Oslo and Akershus University College of Applied Sciences (HiOA)
- Inger Christin Borge, University of Oslo
- Johannes Kleppe, University College of Southeast Norway (HSN)
- Klara Hveberg, University of Oslo

The involvement of people from different institutions emphasises that the videos produced are not owned by a single institution and should be viewed as a national resource.

After five weeks of production, spread out over 2015 and 2016, the group has made videos that cover most of upper secondary school mathematics from a higher education perspective. These videos are freely available to everyone, although only in Norwegian, at the MatRIC TV web site as a national resource. To this day the group has produced over 100 videos with a total running time of over 1000 minutes.

2.2 Production details

Most decisions about the design of the videos and the presentation of mathematical material were left to the production group. One such design decision was the length of the videos. The original goal was 6–7 minutes, but it did not take too long before the group accepted videos twice that length, and some even longer. Even though research [3] suggests that shorter videos are better for the viewers, our experience as mathematics teachers suggests that the presentation of many of the mathematical topics covered in these videos become too shallow if condensed to just 6 or 7 minutes.

Due to the nature of mathematics, mathematical topics are linked like a spider's web. This links the videos in a natural way, but it would be beneficial if the videos could be linked to or even embedded into web sites on an individual basis. Therefore, the group sometimes decided to combine closely related topics into a longer video. In general, the task of cutting mathematics into smaller, easily digestible pieces without breaking coherence and keeping important links to related topics, is a difficult one from a pedagogical perspective and open to discussion. Just explaining how a single topic or video is related to other topics or videos could take more than 7 minutes, especially if everything is broken down into very small pieces. This explanation could be given as text accompanying the videos, but at the time of the production the group did not know if such text could be made available. This was one of the reasons why we requested that the videos should be "tagged" by its contents, and that these "tags" should be indexed and preferably searchable. Longer videos should also have a "topic by topic" description with time stamps, allowing viewers to jump to a particular topic of interest. Still, in retrospect, when viewing the longer videos, it would be better to divide some of them into several shorter videos.

Each video begins with one of the production team members, the instructor, explaining the video's contents. The viewer sees the instructor's upper body to establish a personal connection. The view then switches to a sheet of paper. From then on the viewer only sees the instructor's hand writing mathematics and hears the instructor's voice explaining what he or she is doing. The hand keeps the personal connection alive and allows the instructor to point as he or she explains the mathematics involved. Some topics might be illustrated more easily with visual aids, but by sticking to "pen and paper" the student can learn how to do mathematics by observing what the instructor is doing, including what things should be written down in a solution of a mathematical problem.

The hand doing mathematics on a sheet of paper is recorded using a document camera. Even though we recorded the videos in a studio with technical assistance, this simple setup opens up the opportunity for making more videos at home or at work at a low cost, adding more theory or examples. If the videos are used as part of a mathematics course, the lecturer could make additional videos with a similar look quite easily.

Even though the videos are recorded using a simple setup, we still had challenges, even in a studio, with getting the light and sound right. Ideally, one wants to eliminate the interfering shadows of the hand and the scratching sound of the pen, and the camera's focus should stay on the paper, not the hand. This might be more challenging to achieve at home, but not impossible.

Whether recording in a studio or at home, there are benefits of working in a small group. When one of us was recording a video, at least one other was watching and listening. It was important that also the person watching understood the mathematics being recorded. This allowed us to react if something went wrong early in a video, and we could discuss the contents immediately afterwards. Since we explained mathematics the way we normally would in a short lecture, and for the most part did not script each video as an actor would, the wording might change between takes, and some sentences might become unclear. If someone was recording such a video alone, one would have to watch it later to check its quality, and by then making changes might be harder to do.

Additionally, while two or three were occupied with recording and listening to one video, the rest prepared the next. This gave the others time to discuss the presentation of the next video when needed and sometimes even testing the presentation on each other. Such discussions were useful even if we had tried to prepare some videos at home before getting together. Therefore, we found out that we needed to be at least four people to use our studio hours effectively, and that more than six might become inefficient.

Another benefit of working together as a group was that it was inspiring to work together and fun to meet likeminded people. It was essential to keep spirits up in a large-scale production. The video project also gave us as a group the opportunity to exchange ideas about how to make good videos and how to present mathematics to beginner students, which was very valuable.

Having people from different institutions meet, is a logistical challenge. The production group met and recorded the videos at the University of Agder's studio in Grimstad, each time staying there for a week, for those of the group that could fit this into their schedule. Therefore, the meetings were few and far between, which was not optimal. In addition, the processing times were often long, meaning the production group, and other people involved in the project, had to wait quite a while after recording ended before they could see the finished product online. This made it more difficult to make changes if new ideas came up after recording ended, and it therefore became important to have clear specifications and agree on what was "good enough". Otherwise, the production period would drag out.

2.3 Mathematical material

For the most part, the mathematical contents of the videos match upper secondary school mathematics, with some notable exceptions. For one, the videos put more emphasis on notation than what is usual in upper secondary school. In higher education such notation is used more freely. The gap between school and university mathematics when it comes to notation was one of the comments made by students in the UHR national mathematics study. We explain commonly used notation and use it in the videos.

The videos cover some related or "missing topics" from school mathematics. For example, in upper secondary school mathematics students learn how to solve sine equations using "inverse sine" ($\sin^{-1}$) on a calculator without learning about inverse sine as a function, even though inverse functions in general have at times been part of the curriculum. This leaves a gap that sometimes mystifies the students about the extra solutions that appear in this and similar situations.

The videos emphasise topics students have problems with according to our experience. Here we have drawn upon the experience of the production group members more than formal research. Examples on such problems include calculations with fractions and powers, why mathematicians define things rigorously, and when a proof is complete. The videos also try to clean up school mathematics by

removing some mystical moments when things simply appear without justification and by adding definitions and motivation that are missing. Mathematics is more than "formulas".

As a guideline for mathematical content, the group formulated the following motto: Upper secondary school mathematics from a university level perspective.

3 RESULTS

The most visible result is of course the set of videos produced. They are made available for everyone at the MatRIC TV web site. In addition, many of the videos are embedded into the web pages of matematikk.org "Trinn 11–13". We have also been approached by teachers wondering if they might use part of our videos together with some videos they have produced themselves to make an integrated web course containing both instruction videos and online problems. In addition, we have data from the web sites containing information about the usage of the videos, as exemplified in Table 1. All of this, together with some personal feedback from our own students, tells us that the videos are used, and hence that they might help students with the transition from upper secondary school to university or college when it comes to mathematics in particular, which was the intention of the project.

A second, not as publicly visible result, is the exchange of experience and ideas between the members of the production group, which we feel will benefit us, as teachers, and our students.

4 TABLES

Table 1 shows how many times the 22 most viewed videos have been played and average view time in minutes. The NORDUnet Kaltura Service [4] hosts our videos, and the data from Kaltura was communicated to us by it-hjelp@uia.no. Note that the videos are only available in Norwegian, and the table lists their Norwegian titles. Also, note that the videos have not been available for the same amount of time hence number of times viewed is not a good measure of the popularity of a video.

Table 1. Video views from January 24, 2016 to January 23, 2017.

Video name	Plays	Minutes viewed	Average view time
Mengder	228	480.147	1.27
Trigonometri	215	1066.558	4.96
Polynomfunksjoner	187	878.892	4.70
Cosinussetningen	169	1497.058	8.86
Når er to vinkler like store?	157	1022.250	6.51
Tallmengder	156	839.870	5.38
Sinussetningen	153	1330.783	8.70
Mengdeoperasjoner	153	770.283	5.03
Finne eksakte verdier	148	657.167	4.44
Potenser og potensregler	143	904.086	6.32
Trigonometriske trekantberegninger	138	1361.346	9.86
Trigonometriske identiteter	134	816.351	6.09
Funksjonsalgebra og omvendte funksjoner	130	2080.188	16.00
Funksjonsbegrepet	130	569.152	4.38
Bestemte integral	120	941.807	7.85
Kvadratsetningene	115	760.653	6.61
Arealer i planet	110	618.131	5.62
ABC-formelen	108	1075.199	9.96
Å fullføre kvadratet	107	743.109	6.94
Eksakte verdier	107	501.061	4.68
Potenser med rasjonale og reelle eksponenter	101	1029.000	10.19
Regning med røtter (gammel)	100	1396.748	13.97

5 SUMMARY AND ACKNOWLEDGMENTS

The purpose of this paper has been to share our experiences making mathematics videos. Some design choices might be specific to our task of helping students with the transition from upper secondary school to university or college, but we hope that our sharing will inspire and help others to produce mathematics videos.

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