

Self-Made Video Tutorials in Math Education: In-Class vs. Online Usage

Stefan Freitag¹⁺ and Bastian Martschink¹

¹ Bonn-Rhein-Sieg University of Applied Science

Abstract. The 2010 International Conference on Chemical Engineering and Applications (CCEA 2010) is a worldwide, multidisciplinary academic conference concerned with research, education and application into all aspects of Chemical Engineering and Applications, etc.

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1. Video Lectures in Math Education at University

In general, mathematics plays a central role in our lives because today mathematics regulates our everyday life with techniques, technologies and procedures, for example coding techniques for credit cards or the drafting of curves and surfaces for construction procedures [5]. Obviously, mathematics continues to be an important element of engineering education and it still represents a major obstacle for the students. Lacking the knowledge of several topics, changing learning behavior and inadequate overall conditions at universities for the repetition of school mathematics were mentioned to be causes for the constantly increasing gap between the initial level of mathematics at university and the prior knowledge of the first semester students [2].

When it comes to engineering education, a German survey dealing with sustainable university development in 2011 has shown that nearly half of engineering students and a quarter of business students [5] cancel their studies and one in four students is still leaving the university without a university degree. Students stated that the most common cause for dropping out of studies in these courses is that academic entry requirements often ask too much of them [1]. During their orientation phase at university and their first semester courses, students decide whether they continue their studies or give it up.

Unfortunately, if a student discovers that he lacks the knowledge needed for the mathematics courses it can be difficult to learn mathematics on your own from textbooks. Often students state that they wish that universities videotape their mathematic lectures and provide them for free. Fortunately, there are a lot of examples where small mathematical video snippets are taped or even whole lectures are provided for free, for example on *Youtube*. An important example in the field of video lectures is the famous *Khan Academy*, which produces online learning material for mathematics since 2007.

Nonetheless there is the problem that a lot of videos cover material which is not fitted to the actual subject matter of the students or just explain too much. Seeing irrelevant information or information which cannot even be understood makes students lose the focus while watching the video. In most cases they stop watching it. Therefore it can be helpful to design video material on your own in order to screen only the information which is needed for your personal class. In this paper we describe how videos are produced at the Bonn-Rhein-Sieg University of Applied Science and how they are used in order to help the students.

⁺ Corresponding author.
E-mail address: Stefan.Freitag@h-brs.de.

2. Usage of Video in Practice

At the Bonn-Rhein-Sieg University of Applied Science the production of videos to support the mathematics lectures started in 2012. There are two mathematics lecturers, who provide the professional input for the videos, and one editor, who cuts the videos and provides a university frame for them, working on the project. Both mathematics lecturers can be seen on the videos and they produce the videos on their own. For the production of the videos there is a full HD camera which is taped to a stilt. The camera is adjusted in such a way that it just films a pile of paper on a table, which can be used by the mathematics lecturers to develop the content for the video. During the video on the paper, the pen and the hands of the lecturer who is producing the video is screened. Additionally students are able to hear the voice of the lecturer. The different video parts are then given to the editor who arranges them in the correct order, eliminates unnecessary parts and adds an introduction and an outro to the video. Afterwards they are converted into .wmv-files and uploaded to the eCollege of the university, where they can be accessed by the students. During the ongoing production there are several criteria for the videos:

- Only 5-12 minutes: The videos are supposed to be used as quick reminders whenever there are some fundamentals missing. It is not the intention to screen lectures completely.
- Mistakes are allowed: Mistakes are corrected in the video. This is communicated to the students in advance.
- Simple explanations: The subject matter in each video is explained as easy as possible in order to be useful even for students with lacking knowledge of mathematics.
- If possible, long videos are separated into small, self-contained parts.

The video are designed to help students who have problems understanding mathematics. Therefore they are kept short such that students do not get frustrated if they are watching long videos and have severe problems understanding even the first couple of minutes.

2.1. Online usage

In order to support engineering students during the transition from school to university the Bonn-Rhein-Sieg University of Applied Science in cooperation with the Fraunhofer Institute for Applied Information Technique (FIT) used the videos for a project that combined the traditional mathematical introductory course with a MOOC (Massive Open Online Course). This course uses the so-called ROLE (Responsive Open Learning Environments) platform of the FIT. The ROLE project is a European collaborative project with 16 internationally renowned research groups from 6 EU countries and China. ROLE technology is “centred around the concept of self-regulated learning that creates responsible and thinking learners” [4]. On the ROLE platform the lecturer is able to develop the open personal learning environments for his students where they work on material that is provided by the lecturer. There are platforms available for several topics of school or university education. A detailed description of the project can be found in [3].

For the collaboration with the Bonn-Rhein-Sieg University the FIT will set up a platform that will be accessed by the students via their online account for the eLearning platform of the university. Thus, there are only little administrative difficulties since the students have to create their online accounts anyway. Next, lecturers of the introductory courses in mathematics were able to create their own spaces on the ROLE platform by using widgets, which are small graphic windows that can be integrated as a small program on the online platform, from the existing compilation of the **ROLE** project.

The course lasted ten days. The first phase is a pre-introduction and lasts three days. The first-year engineering students of the university will be welcomed and alongside information about their upcoming studies the structure of the new introductory course and the platform of the **ROLE** project will be presented by the lecturer. On the following two days the students will work on the **ROLE** platform. This phase is a **MOOC** and thematically deals with the mathematical fundamentals needed for the rest of the course (equations, algebraic signs, brackets and number range). After this online experience the second phase of the introductory course is a mixture of a traditional lecture and the online course. During the next six days, several topics of engineering mathematics, such as trigonometry, powers or roots, are discussed in class.

After each lecture the students are able to log onto the **ROLE** platform and work on the topics discussed earlier that day.

On the online platform the lecturer was able to assemble several widgets, mostly with **OER (Open Educational Resources)** content:

- Videos
- PDF documents
- Exercises
- Calculator, tools for formulas, function plotter
- Forum
- Bulletin board
- ...

Obviously, the videos could be taken from the pool of **OER** found for example at YouTube or the Khan Academy. But for the project at the Bonn-Rhein-Sieg University, the lecturer used self-produced videos in order to present only the content that the students need after the introductory course. Access data showed that the video widget was by far the most important widget on the platform. The average length of a video session was 5:06 minutes. The following figure shows the usage of the video widget on one day:

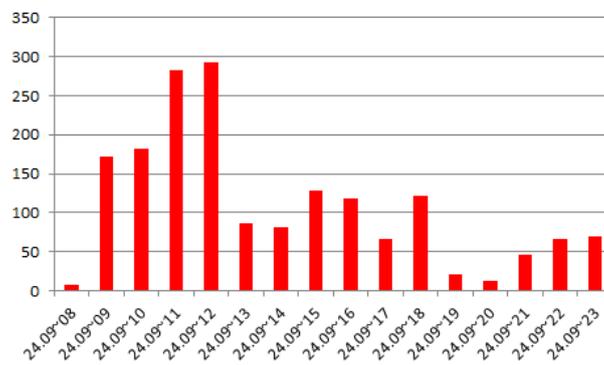


Fig. 1: Usage of the video widget on one day (date~time)

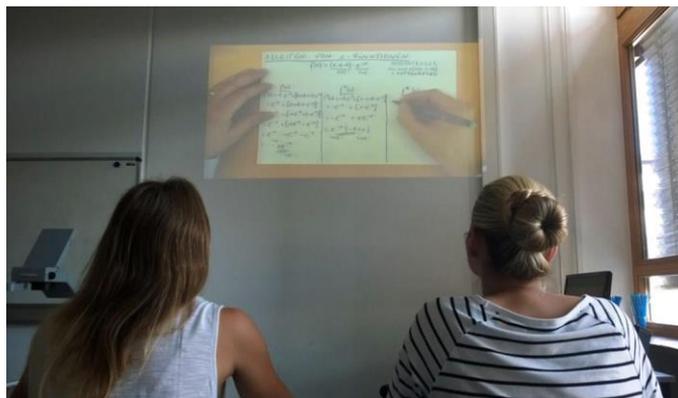
Thus, the videos were highly accessed. On the evaluation sheets students stated that the videos helped them a lot during their process of understanding the topics discussed in class. They appreciated the plain style and that videos were held short. On the other hand students complained about the fact that it took them a long time to download the videos. Additionally they requested the production of video for other topics which have not been covered yet. Using videos only online provides the opportunity for students to watch the video whenever they feel that they have the motivation to do so. Furthermore students stated that they benefitted from rewatching more difficult parts in order to understand the subject matter discussed there. For the lecturer the usage of videos online provides the opportunity to make them accessible for huge audiences and thus there is no limit to the number of users watching the video.

In summary, both the students and the lecturer were satisfied with the video usage. Despite technical problems, videos will continue to be used at the engineering department during orientation at the Bonn-Rhein-Sieg University of Applied Science.

2.2. In-class usage

In the same way as for engineering students business students at the Bonn-Rhein-Sieg University of Applied Science can take an introduction course in mathematics. This course always takes place in the first two weeks before a semester starts. Students have the opportunity to repeat basic mathematical topics from their school days, such as fraction arithmetic, power laws and solving various equations. The students are supposed to be familiar with these topics prior to the start of their studies but in business administration about half of the students are not taking the direct way from school to university. Most of them have previously completed a vocational training in which they have learned the basics in commercial practice at a

professional training school and through on-the-job-training. At university they want to complete their bachelor degree to be able to get promoted into qualified leadership positions afterwards.



Pic 1: In-class usage of video about derivative of an e-function

The course lasts five days and is made up of different mathematical topics, which are first presented to the students through lectures and then deepened by exercises in tutorials. The special feature of this course is the usage of video sequences which are presented to the students at the beginning of a topic. First the lecturer introduces the subject of the lecture or tutorial and describes at which point it should have been discussed in school. Afterwards the video is screened. The video is screened at the beginning of the lecture in order to get a change in didactics. After a short formal introduction the usage of media can grasp students' attention. Switching back to an in-class discussion or associated exercises increases the possibility of students being focused on the subject matter. For the screening process the lecturer uses a beamer with each classroom is equipped. After the video the lecturer and the students discuss the video. The lecturer tries to identify possible misunderstandings, which can afterwards be discussed in class. After the problems of the students are clarified, the students get exercises from the script, which was developed specifically for this course. Due to the different mathematical prerequisites of the students the time for the exercise in class is often not sufficient for some students. Therefore they have the option to download the videos and the exercises from the eLearning platform of the university.

In an evaluation of the course there was a positive response towards the videos and their usage. Students stated that normally it is very difficult to identify OER videos which have a decent quality and highlight exactly the material that is useful for some. Thus, they appreciated that the self-made videos were produced by the lecturer himself because the video seemed authentic and the style of teaching in the video is familiar to the style of teaching in previous tutorials. Furthermore students mentioned that the videos itself were highly informative, precise and useful in order to get to know the material. Also they stated that by switching from the lectured introduction to a different medium of presentation and then to the subsequent exercises students' motivation is longer maintained. On the other hands they complained about some technical problems which occurred seldom in some tutorials. During the first tutorial the equipment in the classroom was not satisfactory because due to the high quality of the produced video the audio track had a time lack. After downloading the video for each session on the computer in the classroom this problem was fixed.

2.3. Summary

After testing the in-class usage and the pure online usage of self-made videos in class it can be stated that in general both approaches worked well and there was a positive response towards the videos from the students. Nonetheless, depending on the situation and the requirements of the course, there are situations in which one of the two models is preferred. We determined the following factors:

- Number of students: If there is a massive audience and the course is designed to be a MOOC the pure online usage is obviously the only option. But even for larger groups it might not be the best option to screen videos directly in class because the level of noise increases. Additionally mistakes in the video or misspellings increase some laughter and the students lose the focus on the actual material presented in the video.
- Time: The video should replace material which is already on the content list.

- Server capacity: If the access rates cannot be covered by the universities' server capacities there is no option to make the students watch the videos online. Otherwise students will complain about not being able to stream it even though they tried it only once.
- Audience: Depending on the level of difficulty of the subject matter it can be better to discuss videos afterwards in class in order to be able to answer the students' questions to come.
- Change in didactics: In order to raise students' motivation and/or get a certain variety in the way of teaching videos can be shown in class.

Furthermore we were able to identify the following aspects:

- Production of videos: Students appreciated videos produced by the lecturer of the actual class instead of **OER** videos.
- Necessity of discussion: After in-class or pure online usage the lecturer should try to get in contact with the students and discuss the material. Otherwise some students do not feel the need to work on their knowledge gaps or on the associated exercises.
- Mobile App: Modern online videos should be accessible via smartphone or tablet computer.
- Constant Access: Videos should be accessible at any time and be located on a server which is constantly online.

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