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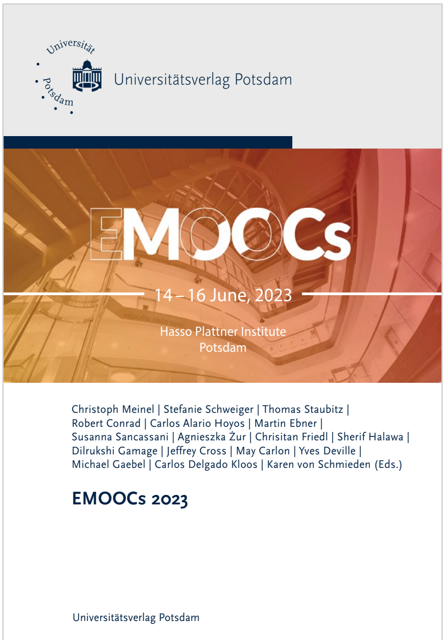

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"One video fit for all"
Game inspired online TEACHING in mathematics in STEM education

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Online learning in mathematics has always been challenging, especially for mathematics in STEM education. This paper presents how to make "one fit for all" lecture videos for mathematics in STEM education. In general, we do believe that there is no such thing as "one fit for all" video. The curriculum requires a high level of prior knowledge in mathematics from high school to get a good understanding, and the variation of prior knowledge levels among STEM education students is often high. This creates challenges for both online teaching and on-campus teaching. This article presents experimenting and researching on a video format where students can get a real-time feeling, and which fits their needs regarding their existing prior knowledge. They have the possibility to ask and receive answers during the video without having to feel that they must jump into different sources, which helps to reduce unnecessary distractions. The fundamental video format presented here is that of dynamic branching videos, which has to little degree been researched in education related studies. The reason might be that this field is quite new for higher education, and there is relatively high requirement on the video editing skills from the teachers' side considering the platforms that are available so far. The videos are implemented for engineering students who take the Linear Algebra course at the Norwegian University of Science and Technology in spring 2023. Feedback from the students gathered via anonymous surveys so far (N = 21) is very positive. With the high suitability for online teaching, this video format might lead the trend of online learning in the future. The design and implementation of dynamic videos in mathematics in higher education was presented for the first time at the EMOOCs conference 2023.

1 Introduction

Receiving real-time questions and feedback from students is the key element to maintain interactivity during a lecture [12, 4, 2]. This is also a positive part of the conventional teaching that needs to be preserved, especially for STEM subjects such as mathematics, in which a good understanding of the previous step can affect the understanding of the subsequent steps [27]. The ability to ask questions in real-time is one reason why live-streaming lectures are more engaging than watching pre-recorded videos [21]. The video format that is presented in this article is that of dynamic branching videos which give the students an opportunity to be simultaneously interactive with the instructor and create a feeling of live-interactive lectures with least possible distracting elements. A branching video is a type of interactive video that allows students to make choices and decisions that determine the direction of their learning, creating a more personalized and engaging experience. In this case, the students can click on an info button appearing on the screen at certain points in the video if they need more detailed explanations.

The use of dynamic branching videos for STEM education has not yet been much researched. Mainly, film producers and commercial prosecutors have been conducting this method to some degree to engage customers. But this should also be considered as an innovative method to engage students in lectures.

As presented in this article, this video method was implemented for a class of engineering students in a Linear Algebra course in a STEM study program.

The course itself requires a high level of prior knowledge for the students in order to get a good understanding. Due to the large variation of the prior knowledge in mathematics among the students, it can be challenging for the teacher to provide a lecture that can fit every student. The benefit of live lectures is that students will have the possibility to ask questions if they need some recap of the necessary prior knowledge in order to follow the subject. But once the teacher recaps the prior knowledge for one student, it might cause all the other students to feel that they waste time on recapping content they already know well. Some students might also find it uncomfortable to admit their lack of prior knowledge in front of the other students.

With the dynamic branching video that is presented in this article, the students will experience the feeling of live interaction. The total length of the video will vary from student to student depending on the amount of recap that they need.

There are two key elements in this video format. One is the suitable interactive elements that are provided by dynamic branching videos, and the other is the fundamental video footage where the teacher is visible along with the content.

2 Literature Review

There have been several studies and works published on the use of videos in online education. Many of these focus on the length and the content of the videos, and how it affects online teaching and learning, see e.g. [5]. In many cases static videos contain long monologues, making the students act as passive learners. The lack of interactivity compared to the on-campus live lectures is not beneficial to the student engagement [24].

To make the online lecture more engaging, there are several central pedagogical aspects that are relevant. One aspect concerns the way the base of the video is set up, for instance from the recorder's aspect. We consider the effect of visibility of the instructor, the use of gestures, and the effect of eye contact from the lecturer. Furthermore, we consider the importance of these aspects for cognition and learning in general and more particularly in which way they are implemented and used in online teaching. How to interact with students, so that they can receive a more suitable lecture and being more engaged is the focus of this article. We also take into consideration the content and length of the videos to make it easier for students to get engaged and focused [18, 26].

2.1 Visibility of instructor and gestures

The presence of the instructor's face in video lectures has been documented to have an affective benefit among students [17, 23]. The instructor's visibility in online lectures makes it possible to provide social cues like face expressions, gestures and other body language, as well as providing eye contact, thus maintaining a traditional classroom feeling for the students [7, 19, 8]. Such types of video presentations have been studied and found to improve the perceived social presence and at the same time reduce the cognitive load as compared to more traditional video lectures in which the instructor's face was present in a separate window, or just using voice-over [16].

The effect of embodiment has been particularly demonstrated in mathematical cognition. This was investigated in detail in a study presented in [3]. In this research, three types of gestures were studied that "manifest the embodiment of mathematical knowledge", namely pointing gestures, representative gestures, and metaphorical gestures. Each of these may contribute to improved visual perception for the students.

According to [3], by using pointing gestures, the instructor connects the spoken content and the associated mental processes to the physical content shown on the blackboard. This will reduce the cognitive load for the students and thus aid their comprehension and learning. With the innovative digital teaching techniques

"Teach Us", the teacher will appear in the same window as the content and create an eye contact feeling for the students while teaching which makes it more engaging for the students [25, 11, 13]. The method is shown in use in Figure 1.

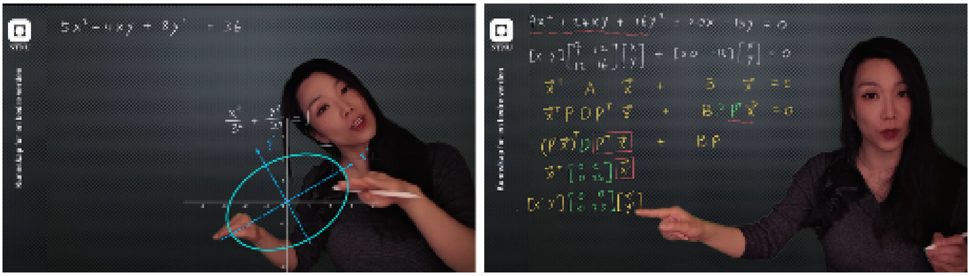

Figure 1: Examples TeachUs

2.2 Interactive elements in lectures

There has been various research on interactive videos, e.g. videos where students can write comments or questions that are attached to the timeline, which make it easier for the teacher to find where in the video the question was asked [15], or more commonly where the interactive elements will pop up in the video either by the choice of the teacher or the students. This extra content can be, e.g. additional information or quizzes during the video [20, 14]. Such interactive additions are meant to increase student engagement. According to the research, these measures did increase student engagement compared to static videos [22, 1]. This of course somewhat depends on how well the teacher has planned the video and pop-ups. In some cases, it might instead create more distractions.

In addition to the interactive elements in the video to maintain the students' focus and engagement, the length of the video content has also been investigated in previous studies [5, 20, 22].

For example, a study carried out by Carmichael et al. (2018) [6] shows elements that make education videos successful for students to gain the intended learning outcomes across disciplines. They found that shorter videos or segmentations on a longer video are beneficial, and the videos that include the teacher's image are more engaging. This way the videos might affect student motivations, confidence, and attitudes positively. Flipped classroom is given as an example of usage of the videos.

3 Methodology

3.1 Participants and feedbacks

The original testing group for dynamic videos was online students. But since we have a small group of online students this year, we are also allowing some of the on-campus students to participate.

The students signed up to participate in the video project by submitting their university email in an anonymous survey. For online students, information about this survey was sent to them via email along with the course evaluation for the Linear Algebra course. While for on-campus students the link for the survey was only provided during a 15-minute break between two lectures. So only the students who were on campus in the class that day got the opportunity to sign up. In total, around 40 students in the Linear Algebra class signed up for this dynamic video project.

The link for the dynamic video was only sent to students who signed up for this video-project, and these students were asked to answer an anonymous survey after they had watched the video. The surveys were made in Microsoft Forms, and the link for the survey is displayed as a QR-code at the end of each dynamic video.

The 4 questions asked in the survey were:

1. What do you think of this video format compared to other interactive videos you have seen? (choose one or more alternatives)
    a) It is more suited to my learning needs
    b) I achieve a better learning outcome and feel more concentrated
    c) I have not seen any other interactive educational videos before
    d) Other (describe/explain)
2. I feel that I have achieved a better understanding of conic sections after having watched the video (Likert scale 1–5, where 1 is completely disagree and 5 is completely agree)
3. I am satisfied with this video format (Likert scale 1–5 where 1 is completely disagree and 5 is completely agree)
4. Do you have any other thoughts or suggestions?

The students were also interviewed orally for additional feedback on the dynamic videos. These interviews were carried out during the digital interactive classes in Microsoft Teams for online students, and during breaks between the lectures for on-campus students. They were asked what they think about the branching videos in general, what they liked about the new video format compared to the other mathematics-related video formats they have seen before, and about any suggestions for improvements.

In addition to the student groups, the author and a team of three members with key competence for this project were gathered both for the purpose of the quality of the dynamic videos, and as participants to give constructive feedback – one physics associate professor who has over ten years of experience in online teaching, one digital media designer with long experience in videos and graphics and one chief engineer with wide knowledge in video related hardware.

3.2 Three milestone phases

The video project was divided into three phases with a timeline.

Phase one: the first round of dynamic videos and surveys for engineering students in March 2023.

Phase two: the second round of dynamic videos and surveys for engineering students in May 2023

Phase three: a larger scale of dynamic videos with a larger group of economic students in autumn 2023.

Video topics in phases one and two were chosen by the students through an anonymous survey. The topics that were suggested by students were typical topics that many students struggle with in the Linear Algebra course.

The data in this article is all the data collected in phase one. The design and implementing of dynamic mathematics videos in higher education was presented for the first time at the EMOOCs conference.

3.3 Planning of dynamic videos

As previously mentioned, dynamic branching videos have not been a widely used video format, so there is not so much information online that helps to determine the choice of the most suitable types of software/platforms, etc. This makes the planning part more time consuming, since the decision on a final platform needs to be made after proper and thorough tests with all the functions that might be needed for the videos. In total 15 possible candidates for platforms were selected and investigated. Among them five were tested thoroughly. Each of the platforms has its strengths and flaws which required adjustment from the author to adapt while making the video. Two of the candidates made the cut for making the final version of videos for students. One is Ekostudio[1], and the other one is Adventr[2]. Since both of the platforms have the necessary features needed to make the proper dynamic videos, the choice of which one will be the most used will be decided based on the students' reported experience of the platforms. A few videos were made in these two platforms to have a fair comparison.

One of the most important parts of creating dynamic branching videos is planning. That is, to have a proper clear roadmap for the video. When the video is divided into small video units, it can easily become chaotic, especially when you need to branch the videos correctly with the least possible errors. Figure 2 shows a road map of the planning of the dynamic units, with the order of the video units indicated by numbers, and arrows that show the branching relations between them. It is also important to keep the roadmap updated in case of modifying of the actual video units in the platforms.

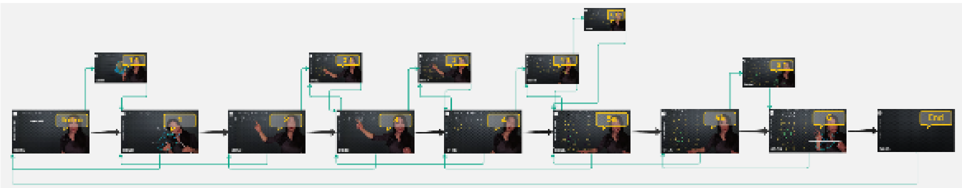

Figure 2: Roadmap for dynamic video made in Miro

The videos were divided into shorter units in Adobe Premiere Pro and uploaded to these two platforms. Figs. 3 and 4 show the interface of these two platforms. The videos were shared with the students via the author's personal webpage [9, 10].

Students can "ask" by clicking the overlay info button that appears on the screen as shown in Figure 5. As mentioned earlier, the dynamic videos can evolve after more feedback and suggestions from the students.

The topics of the videos were based on feedback from the students who are taking the Linear Algebra course in the 2023 spring semester. The one that is shown in Figure 5 is a video about conic section – that is, how to determine a conic section by eigenvalues, eigenvectors, diagonalization of symmetric matrices and orthogonal matrices.

[1] https://studio.eko.com/

[2] https://adventr.io/

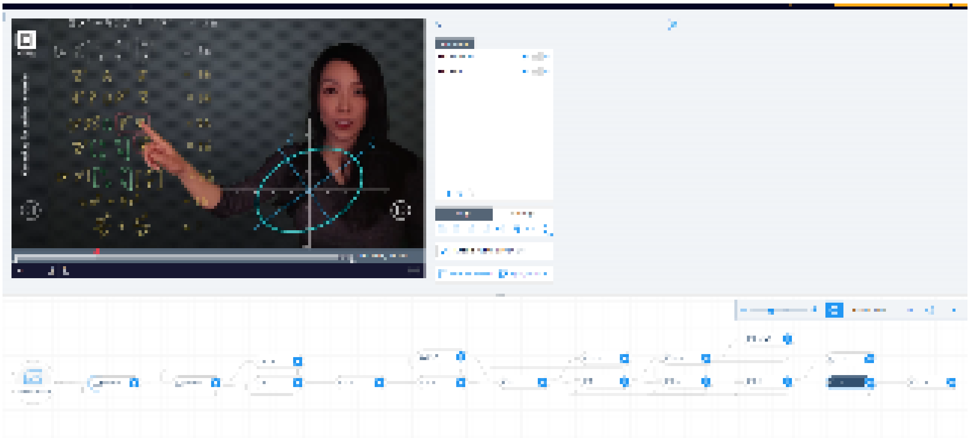

Figure 3: Screenshot from Ekostudio

Figure 4: Screenshot from Adventr

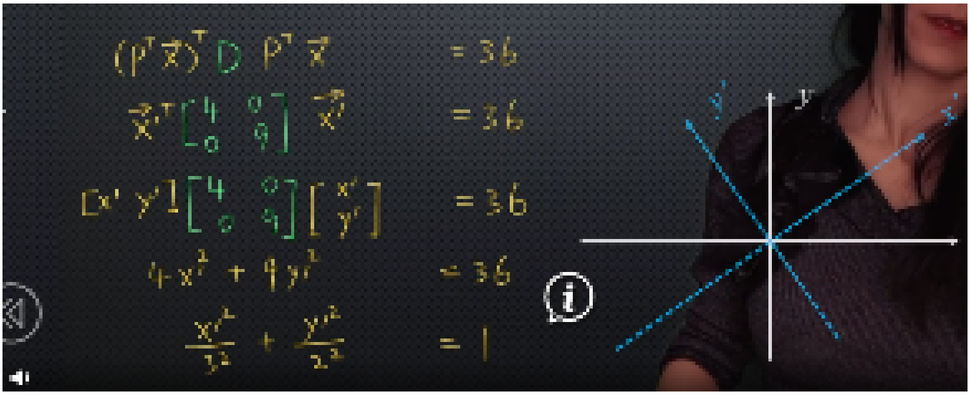

Figure 5: Info-button for branching

The length of the videos varies from less than 10 minutes to over 20 minutes, depending on how many "branches" with additional material the students choose to see.

4 Results

4.1 Student survey and interviews

According to the general feedback from the surveys and oral interviews, all the students were satisfied with the dynamic videos. By the time of writing this article, 21 students (out of the 40 who asked to join) had answered the anonymous survey, and the results are quite uniform.

On question 1, most of the participants did not have so much experience with interactive videos. Three of them had experience with the more common types of interactive videos, and they all expressed that this interactive video format fits their needs better than the other interactive videos they had seen, and they feel it is easier to concentrate.

On question 2 (whether or not their understanding of the topic of the video (conic section) had improved after they had seen the videos), 19 (of 21) responded with four or five stars (Likert scale), where five stars indicate that they completely agree.

On question 3 (how satisfied they are with the branching videos), all the participants rated four or five stars (Likert scale).

On question 4, most of the participants answered that they are satisfied with the videos as they are. One student suggested that the duration of the visibility a couple of the info buttons which indicates possibility for extra explanations could be a bit longer.

According to the feedback from the expert team, the dynamic branching videos that are described in this article make it easier for the students to focus and concentrate on the content.

We received comments through anonymous surveys, as well as follow-up comments through email from some of the students. In addition, oral interviews with the online students and on-campus students were performed. All the comments that we have received so far are positive. Some of the comments we received are given below:

“It feels like one whole video, and it feels like the teacher is giving me a real time lecture that is suited to my math knowledge”.

“In my opinion, the new video reaches a new golden standard for online education.”

“Me and my co-students are super impressed and satisfied with the interactive videos, and we are hoping for more videos like this in the future.”

4.2 Comparison of the (interactive) videos

Two comparisons were made in the anonymous survey. One was the comparison of dynamic branching videos that are introduced in this article to other video formats students have experienced, and the other was to compare the two platforms that were used in making the videos described in this article in order to determine which one will be the more suitable for dynamic videos in the near future.

According to the survey, students in general do not have so much experience of interactive videos, so it is hard to make any clear conclusions. But most of the students have experience with regular non-interactive educational math-related videos. Compared to that category, the students have reported an improved learning experience, improved concentration when watching the videos, and increased engagement.

As for the comparison of the two platforms that were applied in this study, the students could not determine which one was better. During the oral interviews, one student mentioned that the video made with Ekostudio might have smoother transitions in interactive buttons, while the downside is that in some cases the buttons appear a bit too early.

The positive feedback from students might also be related to the main video footage that was made by using the studio “TeachUs”, which has previously been received very positively by the students [11].

5 Discussion

The feedback both from students and from the three team members in this project was positive. Dynamic videos create a more seamless approach of real-time interactive lectures, and it is more suitable for student groups with varying prior knowledge in mathematics. For students who are afraid to ask questions because they feel it might be too basic for the other students will normally choose not to ask in class. But with the dynamic videos, all of the students have the possibility to get a proper follow-up in different parts of the curriculum without being concerned about taking up the time for the rest of the class.

Other factors that might also play an important role in the positive feedback might be that the video clips were filmed with the innovative studio "Teach Us" [18, 19], and the fact that the topic of the videos included in this research are topics chosen by the students, indicating that this is a topic that the students need much help with. The visibility of the lecturer and the possibility for the students to follow the lecturer's gaze and hand gestures might be a positive factor for the students' engagement. The videos offer a high degree of student interactivity and participation due to the interactive elements.

The length of the videos can also be an important factor for the engagement for the students, which was also pointed out in previous studies [5, 6]. This factor was considered in the planning phase. This might result in an increased complete-view-rate of the videos, which will be further analyzed in phase two of the project. We will also perform more detailed surveys in which we will map which factors (length, use of interactive elements, visibility of instructor etc.) the students find most beneficial in this video format compared to other educational videos they have seen.

Although there are many benefits of this new video format, one of the main challenges with dynamic videos is likely to be a high technical threshold from the teachers' side to create such videos. Most of the platforms are still in the development phase, and most of them are aiming for enterprise and commercials. Thus, it can also be challenging for creators of educational dynamic videos to find a suitable platform. In order to contribute to this area, another ongoing research which will soon be finalized will conduct a more in-depth analysis and testing of a large range of platforms that might be suitable for making branching videos like the ones presented in this article. Hopefully it will provide a useful guide for teachers who are interested in creating branching videos and who struggle to find suitable platforms.

6 Conclusion

To provide students in higher education with dynamic branching videos might lead the trend for future digital video teaching in higher education. The combination of teacher's visibility in the videos, and the seamless branching opportunity makes the videos more engaging for students. With these advantages, this innovative video format will hopefully stand out in the research of interactive videos in higher education.

To apply interactive dynamic branching videos in STEM education is still a quite new approach. Thus, their use in higher education has not yet been much researched. Another reason might be the relatively high requirement for mastering video planning and editing skills for videos in this category. The license price is generally high on dynamic branching video platforms for regular uses, which can make it less desirable for more people to try the method. Furthermore, many of the platforms that conduct this kind of video format are still in the development phase, further increasing the challenges for new users.

However, the development of technology is based on the needs of the technology. Hopefully, more published research and experiments like the ones presented in this article will contribute to increased attention to this field, and to further development of the technology, making it more accessible for future online education.

More research data is planned to be collected in the near future, both with engineering students in STEM education as well as with a large group of economics students.

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