MEMI: Measurable effects of mini-lectures on improving student engagement and outcomes

4TU.CEE 2020 proposal by Maria Vlasiou, submitted with the support of the Department of Mathematics and Computer Science, Eindhoven University of Technology.

Background: Learning mathematics and the role of videos

Learning mathematics is a complex process, requiring many conceptual lenses and rich data sources to document and understand students' construction of knowledge (Wilkinson et al, 2018). Rapid development in technology and the widespread use of social media have changed the educational landscape. In today's society, there is a constant influx of new information. Therefore, having the ability to learn by making use of technology that is better suited to deliver knowledge and resources in real-time is a becoming a necessary skill in itself. ***One of the major advantages using technology in education is its effect on raising learners' motivation to learn***. This phenomenon is more evident for the younger generations who grew up using computers in their daily lives. Since this generation is used to the fun activities and various learning tools available in digital realm, traditional ways of learning sometimes does not appeal to them (Gupta & Koo, 2010).

However, despite the increased accessibility of resources, expanded communication opportunities, and enhanced collaborative capacity, not every class fully benefits from the new technology (Pittman & Gaines, 2015). It may be attributed to the ***discrepancy between what research suggests that teachers do and what teachers actually can accomplish***. While previous literature seems to define exemplary technology-integrated teaching as one that embraces learner-centred teaching practices (Admiraal et al., 2017; Ertmer & Ottenbreit-Leftwich, 2010) and teachers' constructivist pedagogical beliefs (Kim, Kim, Lee, Spector, & DeMeester, 2013; Liu, 2011), these findings do not readily match teachers' performances using technology. For instance, even teachers who hold constructivist beliefs tend to implement lecture-based teaching due to their limited understanding of appropriately integrating technology (Liu, 2011).

According to the literature, ***using web videos for teaching has several benefits*** and involves issues of technology, pedagogy, and curriculum content. In the technical aspect, the web video is associated with the bulletin board for deeper understanding of a lecture (Haga & Kaneda, 2005). Pedagogy can use the web video for idea-sharing and for supporting productive discussion (Borko, Jacobs, Eiteljorg, & Pittman, 2008). Video can help learners understand complex concepts which are difficult to explain with simple text and graphics (Tai & Ting, 2015). Furthermore, videos have visual appeal that can evoke emotional reactions from students, which can help increase students' interests and their learning motivation (Hartsell & Yuen, 2006). It has been found that video is among the top six technologies currently used by university professors (Brill & Galloway, 2007) and it conveys the highest amount of enjoyment (Tang & Austin, 2009).

Technology is fully integrated into everyday life, which presents an opportunity in transferring this experience in the classroom context. In the aspect of student use, the popularization of home computers and broadband network connection have increased students' extracurricular use, contributing to the possible development of valuable teaching and learning strategies for in-school learning (Kuhlemeier & Hemker, 2007). The web environments that students are familiar with in their leisure life and the attitudes that they construct toward resources available in the web may mediate their attitude toward the web resources demonstrated in the classroom (Sharples, Milrad, Arnedillo, & Vavoula, 2009).

Specifically ***within the context of learning mathematics in university***, using online videos in university mathematics modules has been shown to have advantages. Perceived benefits of videos include flexibility of scheduling and pace, and avoidance of large, long lectures. In contrast, the main perceived advantages of lectures are the ability to engage in group tasks, to ask questions, and to learn 'gradually' (Howard, Meehan, Parnell, 2018). The same study also showed that students in clusters with high lecture attendance achieved, on average, higher marks in the module. As such, videos provide a useful resource, which should be used in this context only in conjunction with lectures.

Further studies focused ***on the relationship between learning and time spent on lectures and/or videos***. Findings show that students use videos as either a complement to, or substitute for, the lecture, and time spent using either or both resources has a significant impact on learning (Meehan, 2019). Students with low prior achievement, who require more time to mastery, should be advised on how to use videos as complements to lectures in order to scaffold how they spend this time. In conclusion, video lectures should not be used blindly as a substitute for lectures or to the very least instructions should be given to students on how to use this resource.

Objectives and expected outcomes

Designing web technology courses that match students' knowledge background and emphasise students' hands-on experience is imperative yet challenging. In the MEMI project, I seek to incorporate mini-video lectures in an existing course with the objectives of increasing the students' engagement with the course and improving their outcomes.

The course, 2MMS10, is an established Masters course in the core of the *Industrial and Applied Mathematics* Masters programme of the department. It is given in Quarter 1 and comprises three topics in stochastics: Renewal Processes, Branching Processes, and Brownian Motion. The current design involves 4 lecture hours per week, 4 guided self-study instruction hours, three midterm examinations (one on each topic), and a final exam. The material currently offered to students is lecture notes, one single book covering all topics, instruction sets, sketches of solutions to the instruction exercises, and practice exam sets for the final examination.

In this project, further material will be offered to students. Specifically, a number of light board videos will be recorded on specific topics in the area of Renewal Processes. The objectives of the project are:

1. The evaluation of the usefulness to the students of this additional material in terms of improving their engagement with the course.
2. The evaluation of the usefulness to the students of this additional material in terms of improving their outcomes.
3. A report one year after completion on the educational added value of this resource, as measured in three consecutive years / groups (one year before implementation, the first year of the implementation, one year after).

The third objective aims to estimate whether students are triggered more by innovation and are willing to explore new resources *intrinsically due to their novelty* or whether these resources have an inherent added value to students (in the specific context of a specialised and rather challenging first year Master course of the IAM curriculum.)

Project design and management

Last year, the course underwent a redesign which resulted to 50% of curriculum change. My long-term plan is to enrich the course with web technologies, particularly, open source technologies, in which a combination of studios, mini-lectures, presentations and tutorials, class blogs, and wikis is used. I wish however to develop the course in a *measurable, evidence-based, controlled method*, evaluating each step and its effectiveness.

Thus, the overall design of this project is based on the concept of testing the effectiveness of each measure. This translates into a) introducing each intervention one by one to avoid confounding parameters and correlations between interventions and b) designing control groups in order to measure effectiveness.

1. The first project objective can be measured by the students' **a)** class interactions (not measured perfectly, but only based anecdotally on teachers' experience, which is facilitated by the fact that one of the instructors and the lecturer were also teaching the course last year), **b)** their communication with the teachers (measured to an extent through their interactions in the online discussion tool on Canvas and email communication), **c)** their involvement with instructions (measured perfectly by the percentage of exercises completed per student), and **d)** self-evaluation of the students on how engaging they found the material (through questions in the course evaluation and through one-minute papers during class).
2. The second project objective is reasonably well measured due to two control groups. First, a rough indication can be estimated by comparing past results (before the added video resource) to the outcomes (in grades) after the intervention. This estimate is then considerably improved by maintaining a control group not in the cohort of students but in the group of topics examined. Namely, by providing videos only for one third of the topics of the course, a meaningful comparison can be made between the performance of the students in two consecutive years on the topics with and without videos. Under the assumption that students face similar difficulties in all three topics, or equivalently that on average, student grades in each of the three parts are correlated (so on average, students in the year after the intervention do not exhibit unusual talent in one of the three topics), then one can test if there is a statistically significant difference between two years on topics where no videos are offered (to correct for differences in difficulty of the exam and in lecturing nuances) and then compute the difference on the topic of intervention, correcting if needed on the basis of the first answer.

The project will start in Quarter 4[1] of this academic year, where the contents of the videos will be designed. The focus will be on the five main learning outcomes of that topic and one additional point of difficulty. In mid-August 2020 the videos will be recorded, which should result in having this resource ready before each salient point during lectures.

The success of the project is to be measured in two axes: a) the usefulness of the resource in motivating students, b) the usefulness of the resource in improving the learning outcomes of the students. Major risks for the project are: a) that students consider the resulting videos to have little added value on top of the material as regularly offered, because of the limited quantity or because of the format, b) that students find the videos **too** informative and substitute regular resources for the

[1] Due to COVID-19, the project was postponed to 2021. It is initiated in March 2021, with the videos being offered to the student population of Q1 2021-2022.

videos (thus effectively missing out on learning outcomes, because the videos cannot be a substitute for the experienced gained by e.g. practicing techniques on instruction exercises).

After evaluation of the project, the next steps will be mapped out. If the videos have been proven engaging but not improving outcomes, then less time-consuming measures will be investigated on whether they have similar or better outcomes with respect to engagement. If the videos are proven to also improve outcomes, then in the year after, they will be expanded to the second topic, where again a comparison of now four consecutive years will take place. This is a useful design concept, because a resource can reach a plateau, where the amount of information offered is too overwhelming to students to be effective. Thus, evaluating separately also this dimension has intrinsic value. It may be useful to investigate if open source material (such as public videos from other lecturers on a given topic) achieve the same outcome as resources given and designed by the same lecturer. This aspect could capture parts of the question on whether students "simply need more information at a different pace" or whether careful design of this information is essential (e.g. in keeping the same notation or terminology.)

Dissemination and sustainability

This proposal builds on successful past 4TU.CEE proposals, such as ACTION, BULB, "Facilitating the use of recorded lectures", "Flipped micro-lectures: more enjoyable and higher performing classrooms" and so forth. The (preliminary) conclusions of these (and further) projects support the hope that this resource will be useful in the first two objectives of the project. Dissemination, will be through the **a)** 4TU.CEE website, which gives an excellent knowledge base on research innovation in the 4 technical universities in the country. In particular, **b)** I will personally share the outcomes of this project with the PIs of similar 4TU.CEE projects that have served as inspiration. Next, **c)** I plan to submit a short report with the outcome as a case study in a scientific journal on education and technology. Last, **d)** I plan to present the results in appropriate events (such as 4TU.CEE meetings or conferences) within Europe. The European Women in Mathematics association has already expressed interest in issuing an invitation to present the outcomes to the next European Women in Mathematics Meeting in the *Mathematics Education* track, though I will also consider events generally on education too.

Project budget

[redacted]	
Total	**10000**

Signing

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