Do pre-recorded lessons in combination with formative assessments fulfil the learning necessity of engineering students?

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***Abstract*—As an effort to increase digitization of education during the ongoing pandemic in Spring 2021, the course "Electromagnetism II with electric circuits" at Uppsala University has been conducted in a blended form with both pre-recorded sessions and live online sessions. About half of the lectures were live sessions, and the rest were pre-recorded. Among the lessons, more than 75 % were pre-recorded. When the teaching is pre-recorded, the teachers do not get reactions directly from the students, either verbally or from facial expressions. Therefore, self-correcting quizzes were implemented for every lecture, and short formative evaluations were implemented for every lesson. The main objective was to increase the number of students participating in the lessons, which hopefully would lead to more students passing the course. More students watched the pre-recorded lessons than attended the lessons on campus previous years on the course. More students passed the exam on the course compared to previous year, but it cannot be excluded that this is partially or completely due to the exam being different due to the pandemic. The short formative evaluations had at least seven respondents during the first four lessons, but from lesson five and onward, the number of respondents was two or fewer. The quizzes which most students attempted were right after or right before the pre-exams ("duggor" in Swedish), but otherwise relatively few students answered the quizzes. When asked in the course evaluation, it varied a lot whether the students liked, disliked, or were neutral to have pre-recorded lessons, with slightly more students saying they preferred live sessions.**

***Index Terms*—Engineering education, Blended learning, Formative assessments**

I. Introduction

To further support the students in managing their studies, the course 'Electromagnetism II with electric circuits' blended pre-recorded sessions and live Zoom sessions during spring 2021. Blended learning can be defined as "a combination of online and in-class instruction with reduced in-class seat time for students" (Parsad, Lewis, & Tice, 2008, p.1). Before mid-March 2020, all teaching activities on the course were on campus and in-class instruction.

Initially, the plan for 2021 was to make it a blended course with all lectures and a couple of lessons on campus, while most of the lessons should be pre-recorded. Due to the pandemic, the sessions that should have been on campus instead were over Zoom or were pre-recorded. In (Cleveland-Innes & Wilton, 2018, ch.1), blended learning is divided into three different types. The third type is when the activities on the course are both synchronous and asynchronous; when some activities are only on a scheduled time and other activities the students can participate in when they decide to. Looking at this type of blended learning, the teaching in this course during the spring 2021 is blended learning, since it has both synchronous and asynchronous learning activities.

In the course, there are two pre-exams ("dugga" in Swedish). In previous years, the lessons before the pre-exams have high attendance while the attendance on the other lessons is low. Most of the students give an impression of being ambitious, but they do have four courses in parallel, and they seem to prioritize the course that currently has a deadline coming up. Instead of bashing the students for not attending, the teachers thought it would be better to make the teaching opportunities more readily available for the students. With recorded lessons, the students can choose when to take part of the material. When the students have graduated, their future employer will also require them to manage their own time, which this will be a chance for the students to practice on.

When the lessons are pre-recorded, the teachers do not get feed-back directly from the students, either by reading the students' facial expressions, or the students verbally telling the teacher what they do not understand or want to learn more about. Therefore, short formative evaluations were implemented for every lesson. According to (Bennett, 2011), a well-executed formative evaluation should both tell the teacher what the students know and how the teachers should adapt their teaching to accommodate the students' learning. In addition, formative evaluations can also make the students reflect on their learning (Elmgren & Henriksson, 2016, pp.65-68). In total, there will be 22 formative evaluations on the course, one for each lesson, which is more formative evaluations than has been tested before in comparison to the size of the course, the authors' knowledge.

Further, self-correcting quizzes were implemented in 2021 to give the students more feed-back on their learning, and

specifically their understanding of concepts and theoretical framework. According to Freyhult (2019), implementing quizzes that are fully or partially self-correcting is one way during a course to see what the students struggle with and give the students feed-back on their learning. Every quiz is linked to a lecture.

This project has several questions it wants answered:

- Will more students participate in the lessons if they are pre-recorded?
- How many of the formative evaluations will the students answer?
- What information do the teachers get from the formative evaluations?
- How many of the quizzes will the students do?
- Will these implemented changes increase the knowledge level of the students?

The first three questions can be answered by looking into statistics of Canvas; the digital platform used for the course. The last question can be measured in multiple ways, where the most direct one is the results on the exams.

II. Description of the course

The course Electromagnetism II with electric circuits[1] is a five-credit course, which takes place during the fourth semester for energy systems engineering students at Uppsala University, i.e. from January to May/June. The students are enrolled in a five-year program in energy systems engineering[2]. In 2021, 65 students are registered on the course, of whom approximately 35 % are women.

The course contains lectures, lessons, and one mandatory demonstration lab. The first half of the course (part A) has ten lectures and ten lessons, which focuses on electromagnetism, and the second part of the course (part B) has ten lectures and twelve lessons. Generally, the lectures focus on theory and the lessons on computational problem-solving. Every lecture and every lesson is 2x45 minutes. The demonstration lab is at the end of the course and shows practical uses of electromagnetism and electric circuits. The attendance on the lessons previous years are typically high for lesson 1-3 as well as lesson 11-14, but the rest of the lessons only approximately five to ten students attend out of 60-65.

By the end of the course, there is one exam where the students solve problems related to electromagnetism and electric circuits. Half of the exam is on electromagnetism (Part A), and the other half is on electric circuits (Part B). After three lectures and lessons, there is a pre-exam (”dugga” in Swedish) on electromagnetism in the course. If the students get more than 50 % on the pre-exam, they have automatically earned full points (10 points) on the first question on the exam. There is also a pre-exam on electric circuits after lecture and lesson 14, based on lectures and lessons 11-14. If the students get more than 50 % on the pre-exam, they have automatically earned full points (10 points) on the sixth question on the exam, which is the same as the first question on part B of the exam. The students can get the grades U (failed), 3, 4, and 5 on the course, where 5 is the highest grade. The grade is only based on the results on the exam. To get grade 5, the students need 80 % correct; to get grade 4, the students need 65 %; and to get grade 3, the student need 50 %. If the students get less than 50 % on either part A or part B, they have failed the whole exam even if they get more than 50 % in total.

[1]Syllabus for Electromagnetism II with Electric Circuits https://www.uu.se/en/admissions/master/selma/kursplan/?kpid=15810&type=1. Last retrieved 2021–04–19.

[2]Civilingenjörsprogrammet i energisystem 2021/2022 https://www.uu.se/en/admissions/master/selma/kursplan/?kpid=15810&type=1. Last retrieved 2021–04–21. In Swedish.

III. Method

The project implemented self-correcting quizzes, pre-recorded several of the lessons and some of the lectures, and implemented formative evaluations for each lesson. Both the quizzes and the formative evaluations can be seen as formative assessments on the course.

For lectures 1-18, a self-correcting quiz was implemented. Every lecture had a question bank, whereof four questions were chosen at random for each student when they started the quiz. The students were recommended to do the quiz between the lecture and the corresponding lesson.

Lessons 1, 3, 10, 11, and 22 were over Zoom. The rest of the lessons were only pre-recorded. Lessons 3 and 10 were complemented with recordings as well. During lessons 12-19, the teacher also had a Zoom-room open for the students to drop in and ask questions. The lessons over Zoom were live to give the students chances to ask the teacher questions face-to-face and doing student-activited group exercises. In between these opportunities, the students could ask questions through Canvas or e-mail. All sessions also have allocated time in the students' schedule, even if they are pre-recorded. Lessons 1, 3, and 10 were planned to be more interactive with group discussion and exercises in break-out rooms.

Lectures 10 and 12-19 were pre-recorded, while the rest were live sessions over Zoom. For each lecture, there were self-correcting quizzes available for the students. Every lecture has a question bank with 6-12 questions each. When the students start the quiz, four questions are chosen at random for the student to answer. Some of the quizzes take three random questions from the current lecture, and one random question from a previous lecture. For lecture 8, there was also a voluntary assignment where the students should write a short text about a problem in electromagnetism; this complemented the self-correcting questions. The quizzes were made as the course went on, but were made available for the students latest on the same day as the corresponding lecture. During part B of the course, the teacher was available on five occasions when there were pre-recorded lessons, in case the students wanted to ask questions.

For Part A of the course, i.e. lectures 1-10 and lessons 1-10, the recordings were done through Canvas Studio. For Part B of the course, the recordings were done over Zoom.

Each lesson has a short formative evaluation, which the students are encouraged to answer. The questions on the formative evaluations were:

1) What is your general impression of the lesson?
2) Is there any specific part which the teachers should focus on improving?
3) What was the muddiest point during the lesson? What did you find most difficult to understand during the lesson?
4) Do you have any other thoughts on how to improve the lesson?

The students could answer from 1 (awful) to 5 (awesome) on the first question. Question 2 had the different problems solved during the lesson listed and an option to comment on the question. Question 3 and 4 were free-text answers. Using the same question every time was on purpose so that the students could answer the formative evaluation quickly. The first lesson it took the students around 4 minutes to answer the survey; from lesson 2 and forward, it took the students 1-2 minutes to answer the survey. The short evaluations were closed on the morning of June 4th.

All courses at Uppsala University have to have a course evaluation. In the course evaluation for this course, the students were asked what they thought of the lectures and lessons, how much they preferred to be pre-recorded, what they thought of the quizzes, and the formative evaluations on top of the normal questions.

IV. Results

This section goes through the questions asked in the introduction one at a time. An analysis of the whole project can be found in Section V.

A. Will more students participate in the lessons if they are pre-recorded?

Looking at the number of students viewing lessons 2 and 3, see Figure 1, that is approximately the same number of students who used to attend lessons 1-3 previous years. In Canvas, the number of viewers is shown for each minute of each video clip; in Figure 1 number of views is shown for the first minute and during the second last minute. From Lesson 4 to 10, the number of viewers is higher than attendance during previous years. Most students watched the recordings the same day as the lessons were in the schedule, which is also when the students answer the formative evaluation. For the lessons and lectures which were recorded over Zoom and then uploaded to Canvas, it was unfortunately not possible to retrieve the number of viewers.

In the course evaluation, it is very different from student to student if they want pre-recorded lectures and lessons or not, or if they even have a preference. Slightly more students prefer not having pre-recorded lectures and lessons, see Figure 2. The students mention the flexibility on when to watch the lesson as an advantage with pre-recordings, and the missing opportunity to ask or interrupt the teacher as a disadvantage.

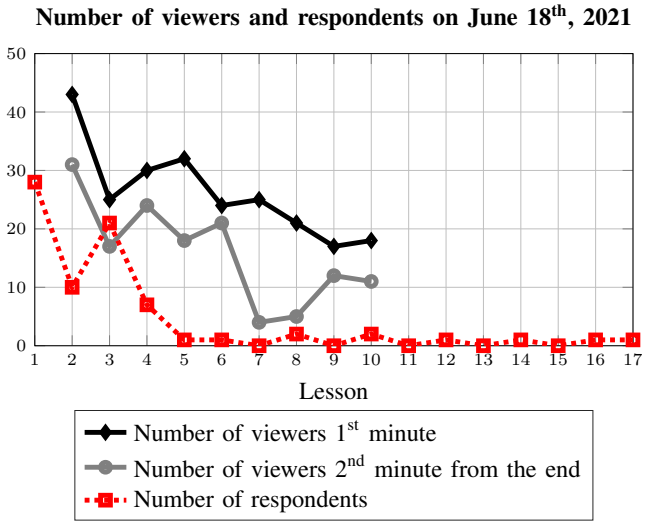

Figure 1. Number of viewers during the first minute and the second last minute of the pre-recorded lessons. Data was retrieved on June 18th, 2021. Lesson 1 was only over Zoom. From lesson 18 and onward, there were no respondents on the evaluations.

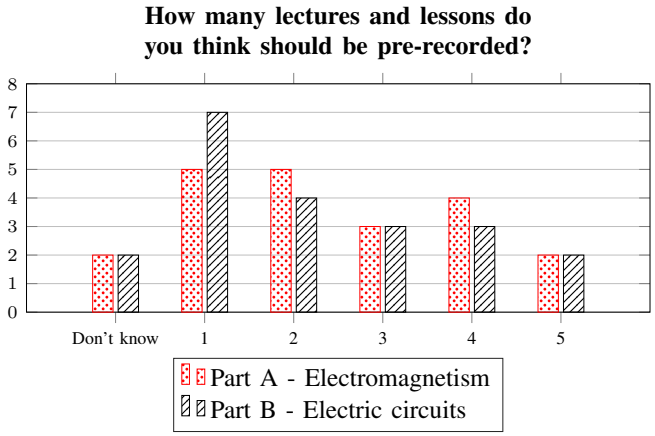

Figure 2. Results from the course evaluation when the students were asked "How many lectures and lessons do you think should be pre-recorded?". 1 stand for no pre-recordings and 5 for everything should be pre-recorded.

B. How many of the formative evaluations will the students answer?

The number of respondents on the formative evaluations for each lesson can be seen in Figure 1. The number of respondents decreased exponentially the further the course went on. From lesson 5 and forward, there have been 0-2 students responding to each evaluation. The highest number of respondents are for the lessons that were over Zoom and early in the course. Generally, it took the students approximately 4 minutes to answer the evaluations for lesson 1, and 1-2 minutes for the lessons after that.

The formative evaluations with more than five respondents were answered mainly on the same day as the corresponding lesson was in the students' schedule. A couple of students answered the evaluation up to four days before the lesson or up

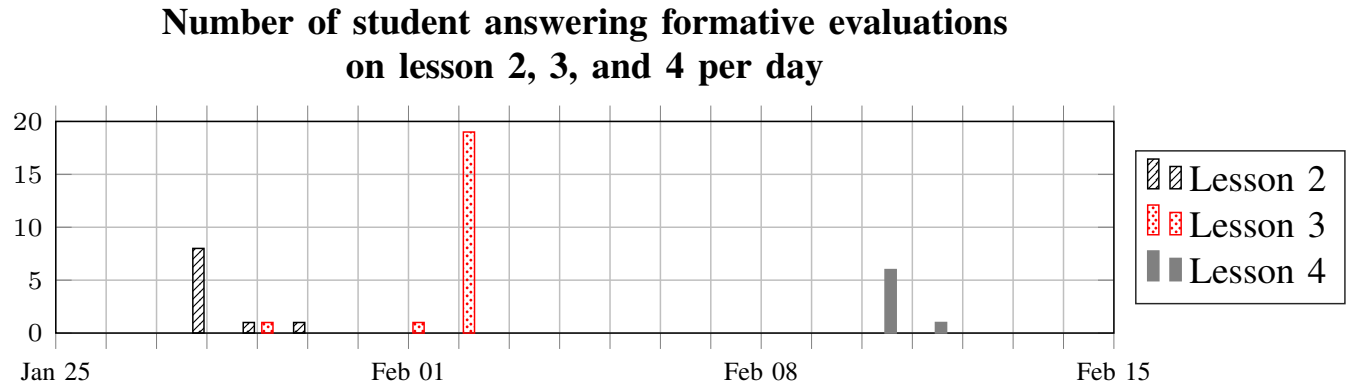

Figure 3. Graph showing which day the students answered the formative evaluation for lessons 1 to 4 and how many students answered the survey that day.

to two days after it. Statistics for when the students answered the formative evaluations for lesson 2, 3, and 4 can be seen in Figure 3. For lesson 1 all students answered the formative evaluation the same day as the lesson was in the schedule.

C. What information do the teachers get from the formative evaluations?

The formative evaluations for lessons 1-4 were helpful since they showed clearly that the students struggled with problems where cylindrical or spherical coordinates were applied. The students should have learned about non-Cartesian coordinates in previous courses, but it is useful knowledge for the teachers on this course that there might be a knowledge gap when it comes to cylindrical or spherical coordinates.

Another part of the same question is what information the teachers did *not* get from the formative evaluations. In the course evaluation, the students said there was poor sound and image quality in the lessons and lectures recorded over Zoom. The students did not say that in any of the formative evaluations.

D. How many of the quizzes will the students do?

It varies a lot how many students do each quiz, see Figure 4. The quizzes for lectures 2 and 11 had the highest number of students doing the quizzes; 18 students (28 % of the registered students). Two students (3.1 %) attempted the quiz for lecture nine, which was the lowest number of students. On average, 7.6 students (12 %) attempted at least once on each quiz.

E. Will these implemented changes increase the knowledge level of the students?

In the 2021, the share of students passing the exam was 54 %, which can be compared to that 40 and 30 % of the students passing the exam in 2020 and 2019, respectively. There were also more students taking the exam in 2021 compared to 2020 and 2019. In Figure 5, the number of students writing the exam and their grades can be found. Since the exam in 2020 also was online, the higher number of participants and passed students can be partially due to the implemented changes described here, but also because the students were allowed to use lecture

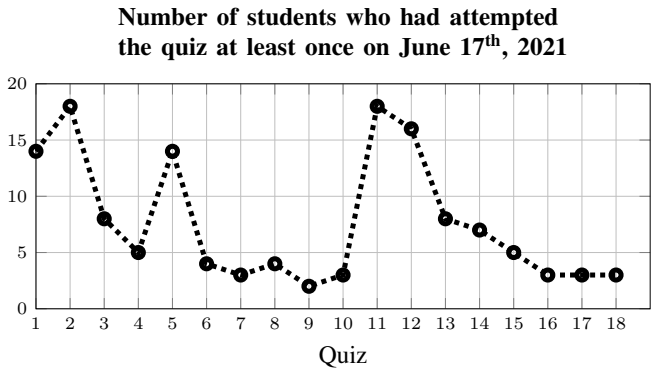

Figure 4. Number of students who had attempted the quiz at least once on June 17th, 2021.

notes on the exam in 2021, which they were not allowed to in 2020 or 2019.

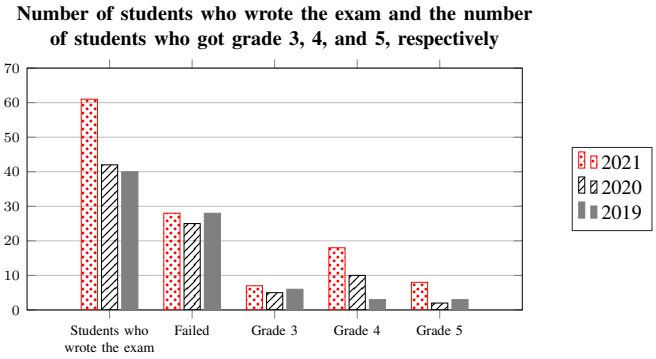

Figure 5. Number of students who wrote the exam as well as the grades received by the students in 2021, 2020, and 2019, respectively.

V. Discussion

As many other probably also has experienced, the pandemic has pushed us, both teachers and students, into digitized education and forced us to learn and develop a lot in a short amount of time. Some parts of the digitization have been good;

for example it is more flexible when the recording of a lecture or lesson is done, as long as it is done before the lecture or lesson occurs in the schedule.

A drawback, which the students also point out in the course evaluation, is the lack of immediate feed-back between teachers and students. The plan was to partially overcome this through the formative evaluations after each lesson, but with the low number of respondents from lesson 5 and forward that did not work. Even if the number of respondents would have been high throughout the course, the formative evaluations do not mean that the students can interrupt and ask the teacher to explain something more thoroughly, so it could never altogether remove this obstacle.

In this particular course, more students passed in 2021 compared to 2020 and 2019. This can be partially due to the students being allowed to have more aids during the exam, but also because of the changes described in this paper. Exactly how much can be contributed to each is difficult, to not say impossible, to know. The fact that more students have taken part in more lessons should mean that the students, in general, have learned more and therefore been better prepared for the exam. The self-correcting quizzes and the formative evaluations can also have helped the students to reflect upon their learning.

Since there are substantially more material online and available at any time, especially the quizzes and most lessons, those students who failed the exam in May, 2021, have more help to prepare for the re-exams. The students who need to take the re-exams are quite many, and for the coming year they can test their understanding through the quizzes and re-watch the pre-recorded lessons.

The formative evaluations show that the students might have insufficient knowledge about cylindrical and spherical coordinates. The students do not formulate it that way; but as soon as a problem with cylindrical and spherical coordinates was being solved the students point out that as the most difficult part of the lesson. The students had a course in multi-variable calculus in the spring of 2020. Therefore, this knowledge gap might be due to that course having to change into online learning on very short notice and not be a recurring problem. It should also be pointed out that the students do not specifically say they struggle with cylindrical and spherical coordinates; it is a pattern that became visible due to the formative assessments.

VI. Future work

Since a lot of the lectures and lessons have been recorded, that work will not be thrown away. However, the lectures and lessons with poor quality need to be recorded again or the current recordings will be made available for next years students, but with lectures and lessons held on campus as well. For the lessons with good quality on sound and pictures, some might be re-used in 2022 while others will be recorded again. Which of these lesson will be recorded again will be based on the number of students that kept watching the recording until the end.

The quizzes will be kept since maintaining self-correcting quizzes requires very little work; the hard work is to make them from the start. They are not used by a majority of the students in 2021, but some of those students appreciated them; for those students they can be a good aid for the students to self-assess their understanding of the material in the course.

There will not be 22 formative evaluations the comings years on the course. Currently, the plan is to evaluate part A when all lectures and lessons have been held within part A and then evaluate part B at the end of the course. There might also be half-time evaluations of parts A and B, respectively, but that is yet to be decided.

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Lastly, but not least, the authors would like to thank the students. On top of the work you put into your learning and development to become engineers, you have given of your time and effort to fill in surveys and course evaluations. Your contributions are very helpful in the improvement of this and other courses.

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