Continuous Assessment Method Using Scientific Articles as Study Material for Distance Learning

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Introduction

In recent years, the Finnish engineering education has undergone a rapid transformation from traditional classroom-based teaching toward online learning. The primary driver for this has been the increasing demand for distance learning graduate programs. The course “Electromagnetic Compatibility in Power Electronics” was changed to an online course for the 2018–2019 academic year to meet the demand created by a new study program for distance learning graduate students. Hence, new teaching and assessment methods were needed to enable the web-based delivery of the course but also to consider the profile of the students in this new program. Most of the students had received their B.Sc. degrees several years earlier from universities of applied science and had somewhat different background knowledge and skills compared with students continuing their M.Sc. studies at the same university directly after their undergraduate studies.

With the transition to the online format, the modified course was built upon weekly online lectures accompanied with a weekly scientific article. Scientific articles were chosen for study material mainly because an up-to-date fundamental textbook was not available. However, during the course it was noticed that especially the students in the new distance learning program had poor awareness of good sources of literature and rather weak scientific reading and writing skills. As one of the aims of the distance learning master’s program is to prepare students for doctoral studies, it was considered necessary to pay attention to the development of the more generic academic skills in addition to the specific Electromagnetic Compatibility (EMC) related objectives, and the use of scientific articles was considered to provide a useful tool for that.

Since assessment was recognized as the element that directs the students’ actions most, a continuous assessment method with weekly quizzes was adopted. The questions of the quizzes were on the scientific article but also reflecting on the lectures and the assessment method. The continuous assessment accounted for 30% and the final exam 70% of the final grade. During the academic year 2019–2020, the students completed a series of questions on the article that they read and answered a final survey that included questions about the study method applied in the course. This paper discusses the observed challenges and benefits of the described instruction method and the students’ opinions of the scientific articles as a study material.

Description of the course

In the curriculum, “Electromagnetic Compatibility in Power Electronics” is a first-year master’s level course. Doctoral students can also take the course and include it in their studies if they have not taken the course previously during their M.Sc. studies. The course span is seven teaching weeks followed by one week to complete an online exam. The course has been implemented fully online since 2018, with the lectures being prerecorded videos. When the course was changed to a fully online implementation, a new continuous assessment method was adopted. The continuous assessment method is described in the next section.
Even though EMC issues are universal for all electronics, the course focuses on converter- and system-level issues within the field of power electronics. The outline of the course contents is as follows:

- EMC basic concepts
- Case: inverter motor drive
- Case: PV inverter
- Filter design
- Measurement interactions
- Layout principles

The course contents are not covered sufficiently by a single textbook, and therefore, the teaching material was gathered from various books and research articles. This setup also acted as the starting point for the proposed continuous assessment method.

The proposed continuous assessment method

The continuous assessment method discussed in this paper was adopted to the course to provide a new teaching tool for the online implementation of the course. The method was designed to help the distance students to be more engaged in the course compared to the previous format of the course, which consisted of classroom lectures and a final exam.

Compared with conventional textbooks and equivalent teaching material, the high level of detail in research articles in the field of power electronics and the required prerequisite knowledge level make them less approachable by students. For this reason, the use of research articles in graduate level courses has been mainly adopted in seminar style courses [1]. The proposed method uses these research articles to extend the learning of the students beyond the lecture content. The lecture videos provide the basic knowledge on the topic of the article, but the article advances to a more detailed part of the weekly topic.

Continuous assessment was selected for the course, as it is a versatile method that has been used in different forms and to a varying extent. Earlier studies in engineering education report several benefits from the use of continuous assessment in different disciplines. In chemical engineering courses continuous assessment was found to result in better grades, a higher passing rate, higher student satisfaction, and better engagement with course activities [2]. Similar effects of continuous assessment have been detected in process engineering [3] and civil and mechanical engineering [4]. The positive effects may, however, come with the expense of excessive workload for the instructors [5]. Therefore, a careful consideration of the ways to apply methods of continuous assessment is necessary.

The first part of the proposed study method is to select a research article that fits the scope of the topic taught that week and have the students read it independently. The article does not cover the whole topic of the week but narrows the scope to a select part of it. After the students have read the article, they will complete a multiple-choice quiz. The questions on the quiz are only on the topic of the article, but with most of the questions the students must apply the information taught on the lectures during that week, or previously on the course. Most of the questions are formed so that the students use a relevant equation from the article or interpret the results or figures of
the article. Each week there are four to seven questions, but the questions are very different when it comes to how long it takes to answer them.

The last part of the assessment is to provide feedback to the students on the quiz answers to promote learning. This is done automatically as the quiz deadline closes. The quiz feedback demonstrates how the correct answers were achieved, and which information had to be applied to come to the right conclusions on the multiple-choice question. Once the feedback on the quiz is released, questions from the students on the answers often come up on the course website. This helps overcome misunderstanding on the answers. As an example, two questions from one of the quizzes and their feedback are shown in Appendix I.

The multiple-choice quiz was selected as the method for the continuous assessment for various reasons. Firstly, using multiple-choice questions in assessment is common in engineering education [6, 7]. The method must be steered to promote learning and match the course learning outcomes. The continuous assessment on the articles does not involve engineering tasks, but the concept is used to see if the student understands the text, finds the relevant information from the article, and is able to apply the information from the article. Implementation of the lessons learned from the lecture videos and the articles will take place on a project-based course, scheduled for the next academic year.

One aspect in the multiple-choice questions was that the quantity was kept relatively low, yet the workload per question moderate. These factors force the students to pay attention to each question, because the effect on the grade will be more significant compared with dozens of insignificant and easy questions. Wrong answers were not penalized with minus points, since even one wrong answer per week had a considerable cumulative effect on the final score. Each question had the same weight on the final score, so this was not balanced on a weekly basis.

One of the main reasons for using multiple-choice questions was strictly to limit the workload of the teacher. When the course has tens of students, and this course has approximately 50 students, the time used weekly for assessment is considerable if short-answer questions or equivalent are used [5]. In addition, the use of automated grading will remove the chance of human error in the assessment.

Generic skills taught by the proposed method

The primary function of the proposed method is to use research articles as relevant teaching material on the topic of the course and provide a continuous assessment tool for the teacher. However, also some teaching outcomes related to generic skills were planned as built-in features; for instance, promotion of the students’ academic literacy practices and information retrieval skills are among the learning objectives of the course [8]. In this paper, academic literacy refers to social, cultural and contextual practices associated with academic study (e.g., practices of academic writing), and the student’s ability to apply these literacy practices (e.g., reading and writing of scientific papers) [9,10,11]. Based on the principles of situated learning [12], the targeted generic skills are best trained in the appropriate social and material context, in this case, on the course.
Most of the students taking the course would start to work on their master’s theses from six months to a year after the end of the course. With just over half of the students on the course having received their B.Sc. degrees several years earlier from universities of applied science, their scientific reading and writing skills were expected to be lower than with students continuing their M.Sc. studies at the same university directly after their undergraduate studies. The proposed method aimed to enhance these skills by exposing the students to scientific articles. The questions in the quizzes act as instrumental scaffolding [13], which helps the students to find the relevant information within the articles. The substance-focused quiz questions are accompanied by three questions that encourage the students also to think about their learning experience, and thus develop their self-reflection skills.

The weekly quiz is implemented so that the student must first search the article on the IEEE Xplore database based on the first author and the title of the article. This was done to help the students get familiar with the most significant database of research not just on the course topic but electrical engineering in general. The database is considered to be the most important source for scientific references by the M.Sc. thesis instructors in the faculty, so getting familiar with the database works in advantage of both the future thesis writer and the instructor.

Student weekly feedback on the articles and the method

When implementing a new teaching or assessment method, student feedback is crucial. In addition to inviting the students to reflect their learning experience and thus strengthen their self-reflection skills, it allows the teacher to evaluate the strengths and weaknesses of the method and provides information on possible adjustments required to the method. The student feedback was collected in two stages: after each quiz and with a larger questionnaire before the final exam. The articles used in the course are [14–18] in the chronological order of publication, and Q1–Q5 refer to the article and quiz numbers as they have been used during the course.

After each weekly quiz, the students were asked to answer a set of three statements:
   a) I found the article well written and easy to follow.
   b) The article enhanced my understanding on the topic of the course.
   c) I found the contents of the article relevant and applicable for my future career.
The answers available to the question were with a five-point scaling from ‘Strongly disagree’ to ‘Strongly agree’. The student answers on the three questions asked after each of the five quizzes are shown in Figure 1.

The questions a and b were used to determine the cognitive usability of the articles, whereas question c was used to determine the motivation of the students regarding the particular article. The questions a and b helped determine the applicability of each article as a viable teaching material according to the students. These questions would also help identify articles that would seem to be too advanced or written so that the students could not grasp the relevant information of the paper. In this context, all the five papers were graded in a similar manner, giving very little room for interpretation. The averages for question a ranged from 3.23 to 3.65 and for question b from 3.32 to 3.91. The articles used in Q3 and Q5 received the lowest scores, while article for Q2 scored highest. Yet, these results cannot be deemed decisive in terms of a clear need to replace one of the articles because of issues with the students’ understanding of the contents.
Results of student feedback on the five research articles. The numbers of answers were $n_{Q1} = n_{Q2} = 46$, and $n_{Q3} = n_{Q4} = n_{Q5} = 44$. Q1 to Q5 refer to quiz number.

The answer mean values to question c ranged from 2.86 to 3.25, with all but one article scoring above 3. Nevertheless, the student overall motivation seemed to be average for each article. Based on the student answers, the cognitive and motivating merits do not necessarily correlate with each other. When evaluating a research article for teaching purposes, the article may have merits in either one of the aspects, and both need to be evaluated when deciding whether the article suits the purposes of the course.

At the end of the course, the students were asked to complete a mandatory questionnaire before they took the final exam. The set of questions is shown in Table 1. The answer alternatives for questions 1 and 2 were ‘Yes’ or ‘No’ and for the rest of the questions:

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

41 students completed the questionnaire.

The answer to the first question reinforces the assumption that most the students who received their previous degree from outside of our university have not been using IEEE Xplore as a database for searching scientific references. This demonstrates that one of the goals of the proposed method had been achieved. As for the second question, it is even more evident that the use of scientific articles as study material has been very limited for the vast majority of the students on the course.

The questions 3 and 5 give an overview on the similar questions that were asked weekly as the quiz was completed. Both answers are satisfactory, but in general the articles received scoring just above average. The answers to the questions 7 and 8 give a clear message that some of the papers were more approachable for the students, and they were clearly helpful for learning. The questions 4 and 6 regarding the relevance of topics to the future career of students received the
Table 1. First part of the mandatory questionnaire completed at the end of the course. The mean values and the standard deviation (std) for the questions are presented with n = 41.

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Before the course, I was already familiar with the IEEE Xplore database</td>
<td></td>
<td>23</td>
<td>18</td>
</tr>
<tr>
<td>2. Studying scientific articles and doing tasks regarding the article was a new form of learning for me</td>
<td></td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>3. The articles enhanced my understanding of the topics of the course</td>
<td></td>
<td>3.51</td>
<td>0.93</td>
</tr>
<tr>
<td>4. I believe that the topics of the course are relevant for my future career</td>
<td></td>
<td>3.34</td>
<td>1.04</td>
</tr>
<tr>
<td>5. The articles were relevant for the topic in question</td>
<td></td>
<td>3.51</td>
<td>1.05</td>
</tr>
<tr>
<td>6. I believe that the topics of the articles are relevant for my future career</td>
<td></td>
<td>3.12</td>
<td>0.98</td>
</tr>
<tr>
<td>7. I found that some of the articles were more understandable than others</td>
<td></td>
<td>4.29</td>
<td>0.81</td>
</tr>
<tr>
<td>8. The articles of better quality were more helpful for my learning</td>
<td></td>
<td>4.05</td>
<td>0.8</td>
</tr>
</tbody>
</table>

The lowest gradings of all the questions. This can signal students’ inability to relate the topics of the course to electrical engineering work or a hazy view of their professional interests.

In the last part of the questionnaire students were asked to rank eight different learning methods in their preference. The list ranked by the students is as follows:

1. Continuous assessment exercises
2. Doing calculation exercises
3. Watching a video
4. Completing a project or an assignment
5. Attending lectures
6. Reading articles
7. Reading a book
8. Peer learning

The course implements methods that ranked first, third, and sixth. Continuous assessment was ranked first, and it has been considered to distribute the workload of the students more evenly over the duration of the course compared with, e.g., exams. This more uniform course engagement and attendance is in line with previous studies on continuous assessment [2, 4]. Reading articles and textbooks ranked low as a learning method, and based on the results, it appears that the students prefer preprocessed teaching material. However, considering promotion and development of academic literacy, the students must train their ability to find the relevant information from written material and exercise critical reading. Furthermore, for students less keen on reading, continuous assessment can serve as a stimulus for regular reading activities and thus promote gradual development of academic literacy.

The continuous assessment method has been implemented in some of the prior courses in the curriculum. However, the students who gave feedback are more accustomed to being assessed on the contents of the weekly lectures. The greater familiarity of continuous assessment in comparison with reading scientific articles may also be one explanation to the good rating of the
former and bad rating of the latter. Nevertheless, combining the less favorable learning method of studying scientific material with a much more favored one is hoped to increase student motivation toward reading and promote overall learning.

Watching videos received a higher rank than attending lectures. The flexibility of watching teaching videos compared with scheduled classroom teaching was prioritized by this student group. Further, the flexibility was increased as the videos were implemented in smaller entities rather than a weekly two-hour session. One teaching method that is widely used in a classroom setting, peer learning, ranked last in the feedback. This student feedback was collected only weeks before the restrictions of COVID-19 on teaching in Finland took place, so this will work as an interesting reference for years to come.

Effect of the proposed method on exam scores

The proposed method was first implemented during the academic year of 2018–2019, when the course was implemented as an online course for the first time. During the same year, students from a new distance learning program started to take the course. Other than implementing the proposed method, the course contents remained basically unchanged compared with the previous year.

The final exam scores for the three last academic years are shown in Figure 2, and the numbers of students taking the final exam, exam score mean values, and the numbers of student dropouts during the course are shown in Table 2. The higher number of students taking the final exam from the academic year 2017–2018 onward is due to the new distance learning program. When the exam score mean values are studied, it can be concluded that the change has been minimal. Furthermore, the distribution of the exam scores follows a conventional Gauss curve, with the exception of the few exceptionally low scores during the academic year of 2017–2018 seen in Figure 2 (a).

As for the number of student dropouts during the course, the variance is relatively high. In the academic year of 2018–2019, there were zero dropouts. However, during the other two academic years under study, the dropout rate was just over 10%.

![Figure 2](image_url) Distribution of the exam scores for the academic years of 2017–2018 (a), 2018–2019 (b), and 2019–2020 (c). The mean values are indicated by red dashed lines.
Table 2. The number of students taking the final exam, exam score mean values, and the student dropouts during the academic years 2017–2020.

<table>
<thead>
<tr>
<th>Academic year</th>
<th>n at final exam</th>
<th>Exam score mean</th>
<th>Dropouts during the course</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017–2018</td>
<td>25</td>
<td>65.7</td>
<td>3</td>
</tr>
<tr>
<td>2018–2019</td>
<td>52</td>
<td>67.3</td>
<td>0</td>
</tr>
<tr>
<td>2019–2020</td>
<td>41</td>
<td>66.8</td>
<td>5</td>
</tr>
</tbody>
</table>

The values in Table 3 indicate that the adopted changes of introducing continuous assessment and the use of scientific articles did not improve the exam results or decrease the dropout rates. An explanation to this could be that the benefits of continuous assessment observed in other studies were outweighed by the increase in the cognitive load produced by the articles. However, the results are not worse either, and the possible gains on the generic skills do not show in the exam results. Hence, we argue that the concept is worth continuing while simultaneously searching for ways to support the development of the students’ academic literacy skills.

The number of students attending the course increased as students from the new distance learning program attended the course. Since the academic year of 2018–2019, approximately half of the students attending the course were from the new study program. The students from the distance learning program came from universities of applied science, and they had different background knowledge compared with on-site students, for example in the field of EMC. In this sense, maintaining the exam scores at the same level can be considered successful. Another aspect to the exam scores was that the whole course, including the exam, went through a considerable reconstruction. Therefore, the comparison of the exam scores between the scores before and after the adoption of the proposed method may not provide a definitive comparison.

Conclusions

A new continuous assessment method was implemented on a course “Electromagnetic Compatibility in Power Electronics” during the academic year of 2018–2019. During the second year when the proposed method was used in the course, the students were asked weekly questions about the method, and they completed a more extensive questionnaire at the end of the course. Based on the questionnaire, the method received positive feedback from the students. Continuous assessment was ranked first as a learning method. There was, however, some controversy over the learning methods applied on the course, mainly resulting from the students’ reluctance to reading. Combining a less-preferred task of reading with a more attractive learning method of continuous assessment was found to produce successful learning outcomes, and thus, the method could be used to motivate reluctant readers.

With the new distance learning study program, the number of students on the course was approximately doubled. Yet, the adopted method of continuous assessment did not significantly increase the teacher’s workload during the course. However, the method did not have a significant effect on the students’ performance in the final exam, nor could decisive conclusions be drawn from the number of student dropouts during the course. Nevertheless, the method was found to teach other aspects than the actual course contents, including learning about databases for reference material and training of academic literacy practices. Promoting the development of these aspects is ever more important as the backgrounds of the students are diverse and the
critical thinking, reading, and writing skills are a necessity in the modern information-intensive and increasingly complex world.

References


Appendix I

1. If the transition time of the inverter output voltage is 50 ns, what is the minimum cable length that will result in full over voltage (propagation speed \(v_p=150*10^6\) m/s)? This is referred to as critical cable length in other literature.
   a) 15 m
   b) 7.5 m
   c) 3.75 m
   d) 1 m

Feedback to question 1:

Correct answer: 3.75 m

When the transition time equals 2*propagation delay, we have a critical cable length. So, the propagation delay must be 25 ns.
\[ l_c = t_d \times v_p = 150 \times 10^6 \text{ m/s} \times 25 \text{ ns} = 3.75 \text{ m} \]

2. As consecutive pulses are generated by the inverter, can the over voltage be over \(2 \times U_{dc}\) at any instant?
   a) yes
   b) no

Feedback to question 2:

Correct answer: yes

This is simple superposition of voltage oscillations. Two voltage transients with very little time in between can occur for example when the duty cycle is high. This is usually limited by the minimum pulse time of the modulator, which is usually about the length of a dead time. Of course, dead time depends on the semiconductor switch characteristics, but let’s say that the minimum pulse is something between 40 ns to 2 \(\mu\)s in low voltage applications. The overvoltage oscillation induced by each switching operation will have a similar waveform. When the oscillations sum up, an overvoltage exceeding \(2 \times U_{dc}\) can be present at the motor terminals.