Challenge-Based Modular On-demand Digital Education

CHALLENGE-BASED MODULAR ON-DEMAND DIGITAL EDUCATION: A PILOT

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ABSTRACT

A blueprint for challenge-based modular on-demand digital education (CMODE) was designed to: (a) provide students with a challenge-based learning environment that is learning-centered, rather than teaching-centered; (b) change the teacher's role from lecturing and knowledge providing to guiding, coaching and motivating; and (c) to provide on-campus contact hours that are complementary to an online learning environment. These goals of CMODE are formulated to increase student motivation for learning by providing them with additional freedom and responsibility, while aiming to exploit the potential advantages of challenge-based and blended learning. Based on this blueprint, a pilot program was created in 2019 for the bachelor Mechanical Engineering course 'Dynamics and Control of Mechanical Systems' at Eindhoven University of Technology. A practical challenge was created, which could be completed by handing in six deliverables. The online learning material consisted of six theory modules—aligned with the six challenge deliverables—that contained short weblectures, examples, quizzes and exercises. Finally, a new format for on-campus contact hours was implemented to improve complementarity with regards to the online learning environment.

Using a questionnaire and the student evaluations, in combination with the exam and challenge grades, we evaluated how CMODE affected students' learning and motivation. Preliminary results show better grades than the previous year, while students mention that they feel more motivated to stay on track with their learning.

1 INTRODUCTION

1.1 Motivation

Most educational programs are divided into learning lines that each exploit a classical course structure as depicted in Fig. 1 below. This type of learning line will typically start with several courses that students follow in predetermined order. To learn practical application of the knowledge, student will do a project at the end. One major drawback of this type of structure, is that it does not invite students to actively create their own knowledge or to engage in active learning [1]. Consequently, students will not always be able to see the practical relevance of all course topics, nor see the interrelatedness of all courses until they start with the end project.

To overcome this drawback, a blueprint was designed for challenge-based modular on-demand digital education (CMODE) that could, for example, exploit a sequential structure as depicted Fig. 1 below. The most important aspect of CMODE is a practical challenge that is provided to the students *at the start*. This challenge is divided into smaller tasks that can be completed by handing in a deliverable. Meanwhile, the knowledge required to complete each task is given in an online learning module.

The objective of CMODE is essentially to: (a) provide students with a challenge-based learning environment that is learning-centered, rather than content-centered; (b) change the teacher's role from lecturing and knowledge providing to guiding, coaching and motivating; and (c) to provide on-campus contact hours that are complementary to an online learning environment. These goals of CMODE are formulated to increase student motivation for learning by providing them with additional freedom and responsibility, while aiming to exploit the potential advantages of challenge-based and blended learning.

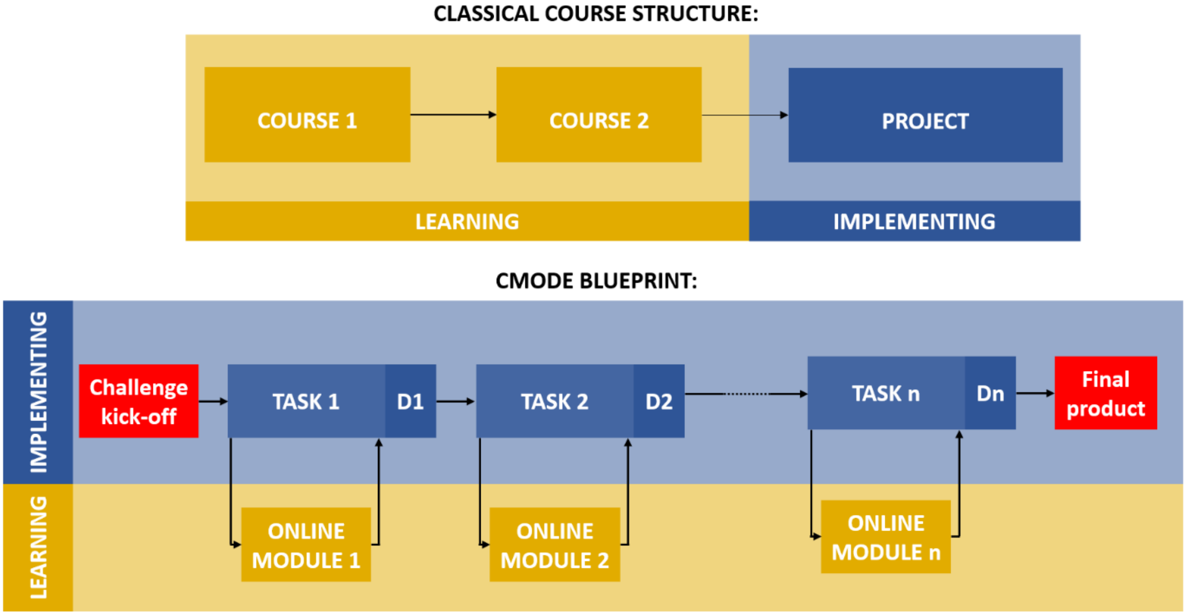

Fig. 1. An example of a classical course structure and the CMODE blueprint. Please note that sequential ordering is not a requirement for CMODE.

1.2 Modular education

In modular education for higher education, an entire educational program, or a subset of course(s) is split up into smaller modules that represent a strongly related set of learning objectives. Generally, upon completion of such a module, students receive credits that are representative of the size of the module. These modules are ideally independent and nonsequential, so that students can follow the modules in an order of their choice. Completion of *all* modules in an educational program results in regular certification of the program [2] [3]. Modularized education is thus a collection of bite-sized units of knowledge and skills, which offers students the possibility to choose their desired educational route and learning speed.

In general, it is argued that modular education provides students with a greater degree of autonomy, and greater responsibility for their own learning [2]. Additionally, it should also allow students greater flexibility to take on modules that belong to other educational programs; under the condition that they are still relevant for their major program. In this way, modular education allows students to develop more specific profiles of competences [4]. Most importantly, with modular education possibilities open up to provide students with education that is more tailored to their individual needs.

Modularization might be perceived as a difficult approach to implement. The coordination alone of all different modules and how they fit together is a daunting task. However, in current times where blended and online education become more popular, it seems that additional options to move towards modular education become available.

1.3 Student motivation to learn and online self-efficacy

Students' motivation highly influences students' learning outcomes [5]. In literature, mostly a distinction is made between intrinsic and extrinsic motivation, where intrinsic motivation is considered as having a more sustainable influence on learning outcomes. Research has shown that student autonomy on what and how to learn, can have positive effects on students' intrinsic motivation [5]. Online, on-demand education, and modular education provide them such autonomy and thus hopefully increases intrinsic motivation.

On the other hand, communicating with fellow students and instructors in online an online setting is different from communication in traditional on-campus offline education [6]. Some groups of students, such as shy students, favor communication in an online environment, whereas other groups of students might feel more disconnected from their educational program and fellow students; or they even feel overwhelmed by all online information [6]. Blended learning essentially offers the best of both worlds. In the next section we will present CMODE, which uses blended learning to provide students additional autonomy in their interactions with online subject matter. At the same time, a physical connection with their fellow students is maintained in on-campus lectures.

1.4 Context: course design

CMODE is developed within a multi-year project, with the intention of providing students with a more learning-centered environment, as opposed to the content-centered environments that are still the reality for many bachelor courses with large amounts $(n > 100)$ of students [2] [7]. In this way, we aim to improve student engagement and intrinsic motivation, to increase the course grades and thus to have a positive effect on the learning outcomes.

For the first year, it is decided to consider a single course that is divided into several tasks and modules. In contrast with modular education, these modules should be completed in sequential order and students can only obtain credits by successfully completing the entire course. For this purpose, a redesign is considered for the bachelor Mechanical Engineering course 'Dynamics and Control of Mechanical Systems' (DCMS) at Eindhoven University of Technology. Due to historical reasons, this course consists of two separate parts: 'Dynamics' and 'Control' that are organized by different research groups. As a result, different course material is used for each part, the lectures are given by different teachers and the final exam is separated into two parts.

Before the academic year 2019-2020, the weblectures for 'Control' were a set of YouTube videos; for 'Dynamics', a set of short 5 to 7 minute videos—recorded in the on-campus recording studio—were used. During the on-campus lectures, the teachers of both parts lectured in a traditional manner (i.e. the teacher provides students with new information in a large lecture hall) and Kahoot quizzes were used to trigger student thinking and learning. The course grade was based on the students' performance during an interim Matlab test and a final multiple-choice exam. In addition, bonus points could be gained by participating in the Kahoot quizzes.

In the evaluations of those years, it was often mentioned that the students regarded the weblectures as a repetition of the on-campus lectures (and vice versa), instead of being of added value. In addition, the students often did not recognize the relation between the ‘Dynamics’ and the ‘Control’ part of the course. Because these parts must be combined in the final project of the learning line—and in many real-world problems—students were often not able to directly apply the knowledge from DCMS in practice.

For the academic year 2019-2020, we used the CMODE blueprint to create a new course design for DCMS. A graphical depiction of this design is given in Fig. 2. The most important aspect of this, was the design of a challenge that consisted of six tasks. These tasks could be completed in sequential order by handing in the corresponding deliverable. In addition, the course material was distributed over six online learning modules that were directly aligned with the six tasks of the challenge. A Formative Assessment (FA) was created for each module, such that students could verify their understanding of the subject matter.

Modules 1–3 related to the ‘Dynamics’ part of the course, while modules 4–6 related to the ‘Control’ part. These were therefore not presented anymore as separate parts of the course, while additional effort was made in modules 3 and 4 to improve integration. Although the modules themselves were presented and taught in a sequential manner; within each module, students were completely free to decide in what order they would interact with the online material. Based on their previous knowledge and experience, students were self-directed towards the material of their choice.

The weblectures were not changed, although they adhere more to what is known about effective flipped classroom designs. The organization of the online part of the course together with the interactive lectures was based on the design as presented in [7]. To avoid repetition in the on-campus lectures, the focus was more on providing examples during the ‘Dynamics’ part, while for ‘Control’ the focus was more on providing intuition and explaining the idea behind the theory.

To support the students in the transition from a traditional educational format to CMODE, several safeguards were added to the course. Firstly, because students were not used to complete freedom and autonomy, a deadline was assigned to each challenge deliverable. Secondly, to avoid a situation where students would only focus on the challenge, they would receive a grade of 0 for any challenge deliverable if they did not pass the corresponding FA.

To ensure that these safeguards would not sacrifice too much freedom, the challenge deadlines were set relatively far in the future. Students could therefore, if they wanted, lag behind the on-campus lectures by two weeks. The FAs were available to the students until the evening before the final exam and they received an unlimited number of attempts.

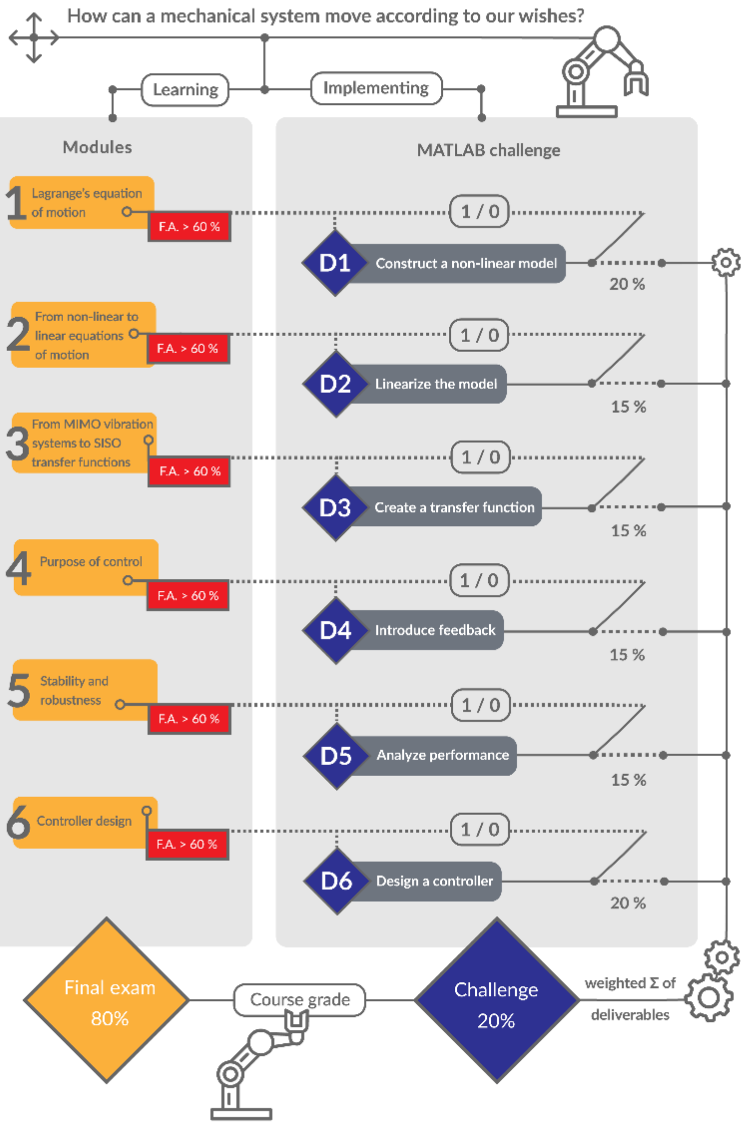

Fig. 2. The DCMS course design that was for 2019-2020

1.5 Problem statement and research question

In this paper, the focus lies mainly on the effect that CMODE has on student learning within the pilot course as described above. With the design of CMODE, we aim to help students interact more efficiently with the online environment and to increase their learning outcomes. Specifically, we are interested in the effects on (1) the students' motivation to learn; (2) student engagement in their own learning processes; and (3) student grades. The research question we therefore aim to answer with this study is:

How does a course redesign, based on the CMODE blueprint, affect student learning and motivation in the bachelor Mechanical Engineering course 'Dynamics and control of mechanical systems' at Eindhoven University of Technology?

2 METHOD

2.1 Participants

Participants in this study were the students of the course DCMS. Of all 369 students, the results on the final exam—which was made by 318 students—and the resit exam—which was made by 50 students—were collected. The 'Readiness for Online Learning Self-Efficacy' (ROLS) questionnaire was filled in by 230 students at $T = 0$ and by 71 students at $T = 1$; of these students, 32 students filled the questionnaire in on both occasions. For the purpose of this concept paper, we focus—for the results of the questionnaire—on the 32 students who filled in the questionnaire on both occasions. Finally, the course evaluation was filled in by 90 students.

2.2 Data collection

Student motivation to learn in this course was measured with an adapted version of the ROLS questionnaire constructed by [6]. In this version, the scale 'Computer/Internet Self-Efficacy' was left out, because this scale measures the students' self-efficacy regarding the use of programs like MS Word and Google. Students in this study were second year Bachelor students and were understood to have these skills, an assumption that the results in [6] supported. Students were asked to fill in this questionnaire online in the beginning of the introductory lecture ($T = 0$). Halfway through the course students were asked to fill it in again ($T = 1$). Student engagement and motivation was also measured using the student evaluations. After the course was finished, students received a link to the course evaluation and were requested to fill it in. This is an evaluation that is send out each year and we used the evaluations from 2019-2020. In addition, the students' final grades were collected from the challenge, the final exam and the resit exam.

2.3 Data analysis

MOTIVATION: After determining reliability of the ROLS questionnaire in this group (Cronbach's $\alpha = 0.799$), it was determined whether the scores for $T = 0$ and $T = 1$ differed significantly for the 32 students who filled in the questionnaire on both occasions with a paired samples t-test.

ENGAGEMENT & MOTIVATION: Student engagement and motivation were analyzed using the student evaluation data. A summary of the responses was made for the open questions that asked students what they liked and disliked about the course.

GRADES: Mean grades were calculated for both attempts of the final exam that were held the current year and the previous year. For the challenge, a mean grade was calculated for all students—that is, including the students that did not complete the challenge. Additionally, we analyzed whether there was a correlation between the challenge grade and exam grade using a scatter plot; together with a Gaussian distribution fit that was used to plot an 80% confidence ellipse.

3 RESULTS

MOTIVATION: The paired samples t-test showed that both measurements highly correlated for all subscales of the questionnaire ($\alpha \leq 0.01$). The means (as presented in Table 1) did, however, not differ significantly, with the lowest $\alpha = 0.121$.

Table 1. Means and standard deviations on the ROLS (5-point Likert scale)

	$\boldsymbol{T = 0}$	$\boldsymbol{T = 1}$
	M (*sd*)	**M (*sd*)**
Self-directed learning	3.33 (*.54*)	3.30 (*.71*)
Learner Control	3.40 (*.65*)	3.28 (*.68*)
Motivation for Learning	3.89 (*.55*)	3.71 (*.64*)
Online Communication self-efficacy	3.20 (*.79*)	3.11 (*.81*)

ENGAGEMENT & MOTIVATION: In the course evaluation, a large number of students mentioned that especially the challenge (and deliverables) helped them stay on track with their learning. Although the students would prefer a reduction in the workload, they observed that the additional work also helped them connect theory to practice; and thus to better understand the subject matter. The motivation to learn that appears from these evaluations is, however, not always intrinsic as is apparent in this student quote: "I did not like it but the deliverables really forced me to study and helped me to connect the theory to a practical application."

GRADES: In 2019-2020, 258 students passed the course on the first exam attempt, while 28 additional students passed using the resit exam. As a result, 78% of the students passed the course in 2019-2020, which is higher than the 68% that was observed in 2018-2019.

In 2019-2020, the mean grade of the first and second attempt of the final exam together was 6.7 (out of 10), while the mean challenge grade was 7.5 (out of 10). This is an improvement with regards to 2018-2019, where the mean grade of the first and second attempt of the final exam together was 6.0 (out of 10). Note that there is no mean challenge grade available for 2018-2019, since it was implemented for the first time in 2019-2020.

A scatter plot of the exam grades and challenge grades in 2019-2020 is provided in figure Fig. 3. In addition, an 80% confidence ellipse is determined by fitting a two-dimensional Gaussian distribution to the data. From the orientation of this ellipse, we can conclude that there is a positive correlation between the challenge grade and exam grade.

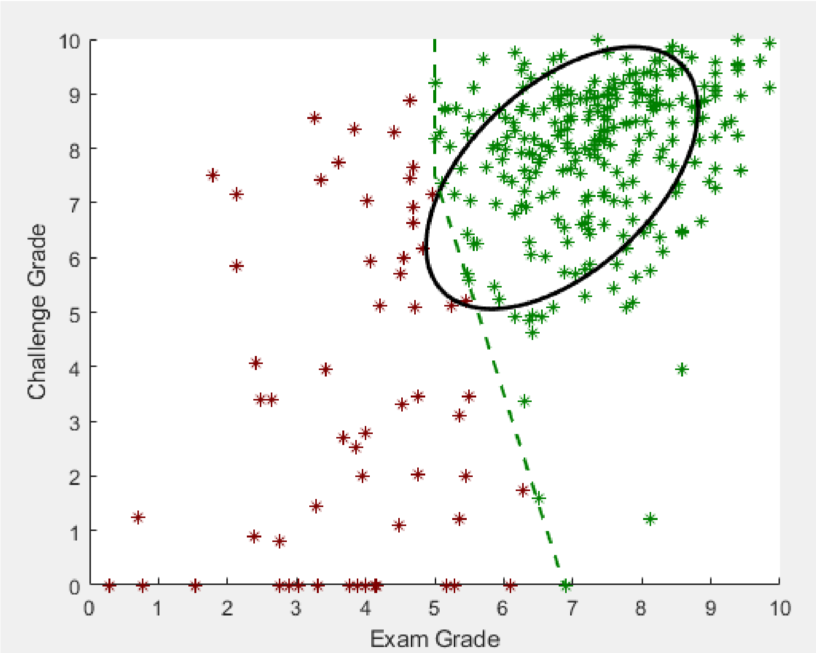

Fig. 3. A scatter plot of the exam grades and the challenge grades of each student, where a green color is used for students that passed the course and a red color otherwise. In addition, an 80% confidence ellipse is plotted.

4 SUMMARY

This study provided us with several insights. First, the preliminary results show no immediate increase in motivation to learn online, nor in the students' online self-efficacy. At the same time, students were also not demotivated by the new course setup, as was feared by several students who took the course in the previous year. Second, looking at the results from the student evaluations, CMODE seems to have a positive influence on student engagement. Especially the challenge (and deliverables) helped students to stay on track with their learning, while simultaneously fulfilling a motivating role. Last, both the mean challenge grade and the increased mean exam grade are a promising result. The positive correlation between the challenge and exam grade, in combination with the students' positive remarks regarding the challenge, leads us to believe that the challenge helps students to focus more efficiently on learning the subject matter; and thus to pass the exam with better results. This is, however, only one aspect of the pilot that deserves further investigation.

Other limitations in this study that will be addressed in the future are the ROLS questionnaire, which will be administered more times in the coming year (3 instead of 2 times). In addition, next year the survey questions will put more emphasis on typifying student motivation. We also want to interview students about their perceptions of the course in relation to other 'traditional' courses. Finally, we aim to collect data to determine whether CMODE prepares students for future courses, such as the aforementioned final project of the learning line.

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