(Blended Learning)^2

Blending content- and learning-oriented objectives in a blended learning environment

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INTRODUCTION

Large classroom sizes are a reality university educators need to contend with, particularly in the first year of a given cohort within a degree programme. Activating and engaging students in these large classroom environments present numerous sets of challenges. These challenges are exacerbated by student learning development needs in the early stages of the degree programme. In their first year, students are still adapting to a new learning environment and are developing new study skills and practices. Early success and failure in courses will shape intrinsic and extrinsic factors that will motivate the student in the remainder of their degree. Thus the perceived challenge of activating large classrooms early in a degree programme goes beyond simple engagement; beneath the core learning objectives of the course are implicit learning objective about developing effective motivation and study skills.

This paper examines the efforts to reorganize a first year Mechanics of Materials course taught in the Bachelor of Engineering Programme within the Faculty of

Aerospace Engineering at Delft University of Technology University to address this need using a *Blended Learning* approach.

1 BLENDED LEARNING

1.1 Definition of Blended Learning

Blended Learning is a popular term these days, however it is not a term without discussion on its exact meaning in educational literature. Graham in his handbook on blended learning distinguishes 3 types of blended education definitions: “combining instructional modalities”, “combining instructional methods” and “combining online and face-to-face instruction [1]. From this it can be seen that blended is not limited to the 3rd definition which in the current times is a very popular one as can be seen from the definition of Alan and Seaman who define blended education as a type of instruction of which “30-80% of the course content is delivered online” [2]. This is also where the critics of this definition of blended come from, mixing different forms of instruction is nothing new: As far back as 2002 Driscoll [3] is arguing to “get beyond the hype” and Oliver and Trigwell [4] contend that the word ‘learning’ is mistakenly used as this is not a new type of learning from the perspective of the student but rather a different method of instruction and pedagogy. However, for the purpose of this paper the third definition from Graham is used: “combining online and face-to face instruction”[1].

1.2 Why implement blended education?

So why go through all that effort to create a blended course? If we look at the evidence blended learning stimulates a more active approach to learning by students resulting in higher numbers of students taking the final exam, improved pass rates and lower drop-out rates [5, 6]. Also according to a meta-analysis as carried out by the US Department of Education [7] blended learning is far more effective than only face-to-face or online learning. It is also fair to say, as argued by Stacey and Gerbic, that the positive effects of blended learning are not caused by the blended learning itself but instead by the required rethinking and redesign of the way lecturers teach [8]. Students also really like blended because of the freedom it gives them in planning their study time and pace. That being the case, as pointed out by Bergman and Sams [9] the primary motivation for a lecturer to switch to a blended approach is to free up class time so that lecturers can work with students when they need support for instance when they are stuck.

1.3 How to implement blended education?

When implementing blended learning it is good to realise that there are more options than just online videos with in-class exercises as proposed by Bergman and Sams [9]. Students could improve their skills using e-tools for instance and in-class not only exercises but also formative testing of deeper understanding and practical demonstrations could be carried out. Indeed, as Gillet argues blended, like online learning, offers students the possibility of a more personalised learning path [10]. To assist with developing blended and online courses the Delft University of Technology Extension School has developed a pedagogical model for online and blended education was developed: the OLE model [11] which defines a diverse, active and flexible course set up offered to student as the backbone of a successful blended course. The model results in a spider plot which indicates the choices made in the course design with regards to the different attributes of the course. For the design of this course this model was used. In Figure 1 the spider plot for the design of this course is given.

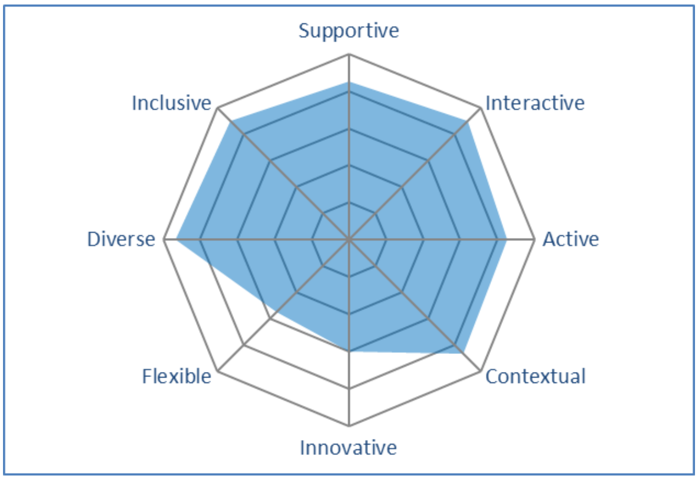

Figure 1: OLE model spider plot for redesigned course

2 ORIGINAL COURSE DESIGN

The course examined in this paper is a first year course in the Bachelor of Engineering programme in the subject area of Mechanics of Materials. The 3 ECTS course has a yearly cohort of approximately 500 students divided into two groups taught by two different lecturers. Each group is taught by a single lecturer for the duration of the course.

2.1 Learning objectives

By the end of the course, students will be examined on their ability to:

- Use mechanics to solve basic problems dealing with the stress, strain, displacement of structures in static equilibrium under mechanical & thermal loads.
- Draw conclusions for basic structural design

2.2 Summary of setup

The previous setup of the course was based on delivery of the course content via 14 “traditional” in-class lectures, each of 2 hours in length, over a 7-week period. These lectures focused on theory development with some simplified examples for demonstrating the application of concepts learned.

A mandatory weekly computerized homework systems was employed to ensure a minimum level of self-study was being completed by the students. As the intent of this homework was promote the self-study of the students to keep pace with the course, grades from the homework did not count towards the student’s final grade. Rather, a minimum average grade requirement across all homework assignments, and across groupings of 3 consecutive assignments was required for entry into the exam. Unlimited attempts to solve an assignment were given prior to its deadline, placing emphasis on the students being able to complete a problem.

In addition to the computerized homework, sets of recommended problems from the textbook were given for each lecture, however, no requirements for completion of these problem sets were made.

An optional weekly instruction session of 2 hours was offered to students where teaching assistants for the course worked on additional example problems and provided additional help to students in a more manageable class size of 30 students.

Finally, students were assessed through a 3 hour written final exam worth 100% of their overall grade. This exam typically consisted of 4 open-answer problem solving based questions.

2.3 Course feedback

Although the course setup was generally well received by the students, results from examinations consistently showed a lower performance by students in portions of the exam that required higher level cognitive domains of Bloom's taxonomy. Furthermore, issues were identified in the ability of students to provide complete and organized solutions to exam problems, making it difficult to assess the student's understanding and solution approach. It was identified that a lack of disciplined self-study beyond the minimum required, and the "final answer only" assessment of computerized homework was likely a contributing factor to these outcomes. Feedback from students also indicated that students found concepts in the course to be intuitive when presented, giving them a false sense of confidence in their ability to apply them.

3 REDESIGNED COURSE

3.1 Objectives for redesign

Based on the feedback received on the original setup of the course, a redesign of the course was initiated. To guide the redesign process and evaluate the worth of proposed changes, the following set of objectives were formulated.

- Refocus classroom activities towards the application of theory and concepts, particularly at the higher cognitive domains
- Improve student engagement
- Instil a greater sense of personal responsibility in the learning and study process
- Provide greater student insight into the learning expectations and the process for assessing them

Before these objectives were formulated, a decision to take a blended learning approach for the redesign was already made. However, formulating these objectives was found to be crucial in guiding and evaluating individual elements implemented in the blended approach.

3.2 Redesigned course elements

The various elements of the course that were redesigned are summarized below. The individual elements will first be described. The next section will describe how these individual elements were combined in the context of the course.

Learning objectives

Although the overall learning objectives of the course did not change, it was felt that providing a more detailed breakdown on how they apply across the various cognitive levels would be beneficial to the students. This was particularly useful with respect to the mock exam element of the course that is described later. The reformulation of the learning objectives is provided in Table 1.

Table 1: Revised learning objectives

Domain	Learning Objective
Understand	Explain the interrelation between force, displacement, internal stress, and internal strain using the Generalized Hooke's Law for Basic Load Carrying Members
Apply	Apply standard force-displacement relations and force-stress relations for Basic Load Carrying Members to solve for reaction forces, displacements, and stresses in statically determinate and indeterminate problems
	Develop force-displacement relations for Basic Load Carrying Members that include varying geometry, material properties, and/or loading
Analyze	Breakdown complex structures into Basic Load Carrying Members with their associated loading conditions using the principle of superposition, equilibrium, and Free Body Diagrams
	Formulate appropriate displacement relations to describe the deformation compatibility of statically indeterminate systems
	Question the validity of magnitude and direction of calculated forces, displacements, and stresses based on their compatibility with loading, geometry, and expected deformation
Evaluate	Assess the influence of changes in boundary conditions, structural geometry, material properties, and loading on the deformation and stress state of a given problem

Blended learning videos

Based on the feedback that students found the key concepts intuitive and easy to follow when taught in a traditional lecture, it made sense to transfer the time spent on this to outside of the classroom. Short videos ranging from 3-10 minutes demonstrating the key theoretical concepts were custom created for the course. As all of the concepts treated in the course are sufficiently described in the mandatory textbook, particular attention was paid to ensure there was added value to the videos. Demonstrations, animation, and other dynamic elements were included to help provide an added value resource to the course. Additionally, a select number of video solutions were created to help reinforce the application of concepts within the course. The complete library of blended learning videos generated for the course are available at https://www.youtube.com/c/CalvinRans in the playlist Mechanics of Materials.

Feedback Fruits

Feedback Fruits is an online polling software application that allows students to sign in with a computer or cell phone to an online environment generated by the instructor (www.feedbackfruits.com). Although this online environment has many possibilities, for this course, only the online polling and real-time question submission features were utilized. Simple polls were generated to gauge the level of understanding of key concepts within the classroom prior to engaging in example problems, and permitting students to raise issues or misunderstandings that could be addressed on the spot in the classroom.

Digital homework (COZ)

The digital homework system used in previous years was retained for the redesign of the course. The online homework system Mastering Engineering, provided by the publisher of the mandatory textbook for the course, was utilized for this purpose. In addition to the mandatory assignments, the system provided a library of additional resources, including additional problems and video solutions for the students to use at their discretion.

Mock exams with peer evaluation

A mock exam exercise was undertaken to address the issues observed in students struggling in providing complete solutions that demonstrate their understanding of the concepts being assessed in the course. The aim of the exercise was three-fold: provide students with practice in solving exam-level questions under exam-type time pressures, familiarize students with the type of assessment procedure/criteria used for grading the exam, and exposing students to common pitfalls and/or best practices in presenting a written solution through peer evaluation. All mock exams consisted of a single problem (1/4 of a typical exam) from a past final exam. In alternating weeks, students carried solved a mock exam under exam conditions in one week, followed by the next week with peer grading of the exam solutions based on a supplied grading model that clearly highlighted the concepts and learning objectives being evaluated.

3.3 Implementation overview

The overall implementation of each of the course elements for a single week is illustrated in Figure 2. Students prepared for lectures via guided learning units organized within the blackboard learning environment. These learning units consisted of a mixture of blended learning videos, short readings, and simple concept questions. Preparation for each lecture (two lectures per week) was limited to 30 minutes of activities, with a margin of an addition 30 minutes for re-watching/reading specific elements and for taking notes. Each two-hour lecture was divided into two parts. This first hour was devoted to employing the Feedback Fruits polls to evaluate the levelling of understanding of specific concepts (and providing supplementary explanations where necessary) and reviewing specific aerospace-related applications where the lecture topics are applicable. The second hour was devoted to solving problems together as a class. To facilitate in the participation of the audience, a throwable microphone was used. Students then were able to further practice the application of the concepts for that week through weekly computerized homework (COZ) and through weekly instructions led by teaching assistants. Within the instructions, the first half was devoted to problem solving and the ability for students to seek help, while the second half was devoted to the mock exam exercise.

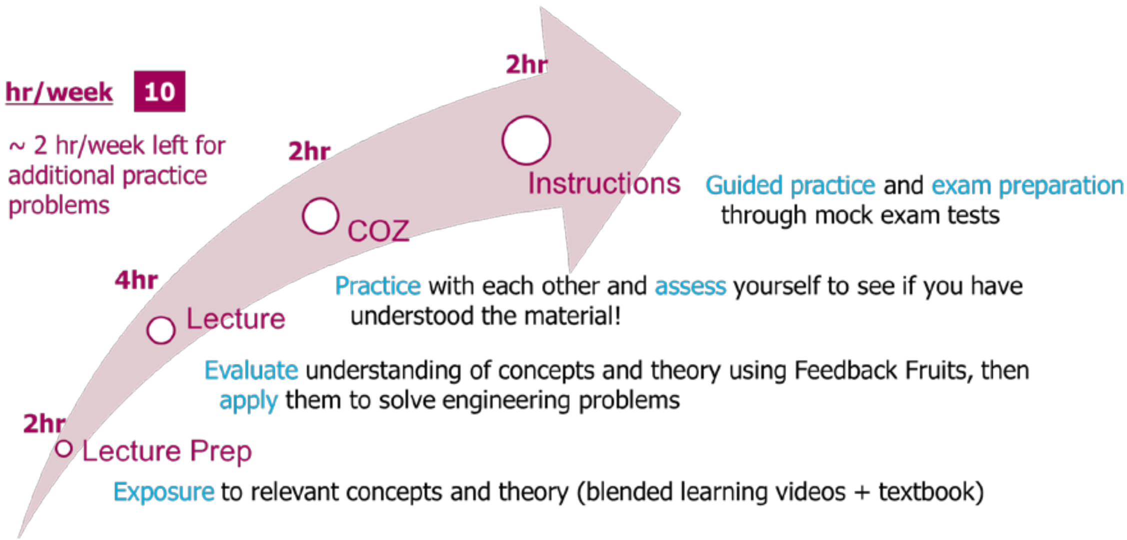

Figure 2: Weekly breakdown of student activities and time requirements

The overall breakdown of the course by week and by topic is provided in Table 2. This table served as the roadmap for the students for the course, being clearly visible as the home screen to the online learning environment and the concluding element shown at the end of every lecture.

Table 2: Lecture preparation, digital homework (COZ), and instruction schedule with common topics highlighted via colours

	First Lecture		Second Lecture		COZ		Instruction
Week	Topics	Preparation	Topics	Preparation	Assignment	Due Date	Activity
3.1	Introduction	None	Stress, Strain, Hooke's Law	L.U. 1 (all)	none	none	no instruction
3.2	Axial loading and static indetermenacy	L.U. 2 (all)	Torsion of circular shafts	L.U. 3.1-3.2	COZ1	18/02/2016	Mock exam 1
3.3	Torsion of thin-walled shafts	L.U. 3.3	Bending stresses in beams	L.U. 4 (all)	COZ2	25/02/2016	Peer grading 1
3.4	Transverse shear stresses in beams	L.U. 5.1	Shear stresses in thin-walled beams	L.U. 5.2	COZ3	03/03/2016	Mock exam 2
3.5	Combined loading	L.U. 6 (all)	Stress transformations & Failure criteria	L.U. 7 (all)	COZ4	10/03/2016	Peer Grading 2
3.6	Beam deflections by integration	L.U. 8.1	Discontinuity functions and	L.U. 8.2-8.3	COZ5	17/03/2016	Mock exam 3
3.7	Statically indeterminate beams	L.U. 8.4	Review	None	COZ6	24/03/2016	Peer grading 3
3.8	Study for Exam						
3.9	Exam - Friday April 8th @ 13:30						

L.U. = Learning unit (refer to blackboard site for learning units)

4 RESULTS AND FEEDBACK

Results of the first examination of students following the blended offering of the course are summarized in the final row of Table 3. Results from both the regular exam and the resit exam from the previous two years are also provided. Although there has only been one examination under the new format, the results from that cohort are the highest the course has achieved in the past 4 years. These results seem positive and at least indicate that there was not a negative impact on student success due to the modified teaching/learning approach.

Table 3: Summary of average grades and pass rates for the previous three years. Grades range from1 - 10, pass grade is 6 out of 10.

Year	Exam	# Students	Mean grade	Pass Rate
2014	Regular	311	5.10	39.2%
	Resit	174	4.70	27.6%
2015	Regular	352	6.25	59.4%
	Resit	118	5.61	49.2%
2016	Regular	303	6.41	66.0%

Another valuable source of information for evaluating the success of a course is student feedback. In order to better evaluate the changes made to this course, an anonymous student survey, designed by the Delft University of Technology Extension School specifically for new online and blended courses, was administered for this course. The survey consisted of Likert scale ratings of aspects of the course in combination with short answer questions.

A summary of the Likert scale results are provided in Figure 3. A total of 83 students participated in the survey, with approximately 60 students providing responses for all aspects of the survey. Given that the course started with 375 registered students, the response rate is reasonably good for an optional online survey.

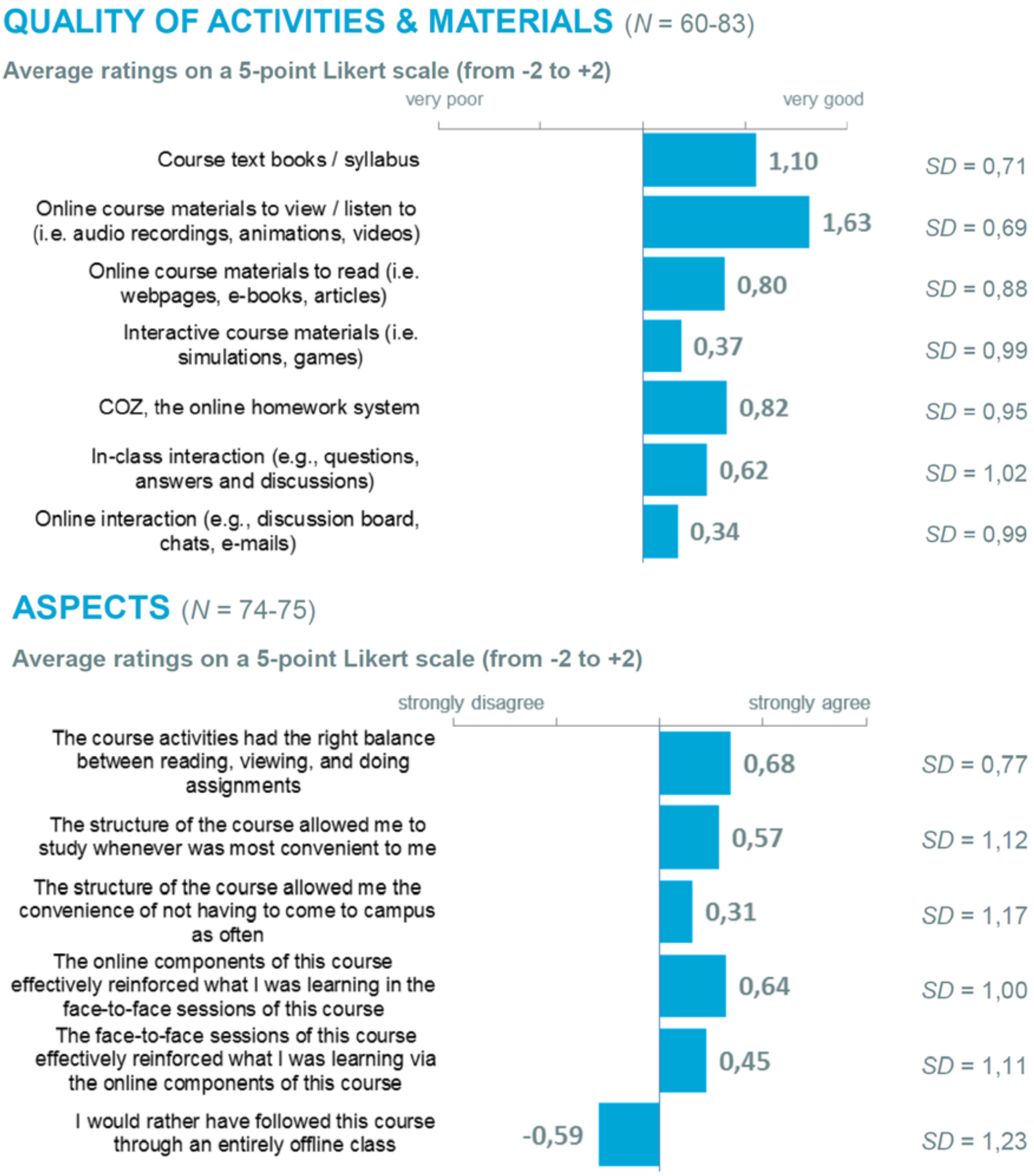

Figure 3: Results from the online/blended education survey.

The results in Figure 3 indicate that the blended approach, and the resources created to facilitate it, were generally well received by the students. Only the final question resulted in a negative score, however, as the wording of this question is negative, this result actually indicates a positive outcome.

The short answer responses/comments of students provide further insight into the reception of the blended learning approach. Both positive and negative comments were received. Amongst the positive comments:

- *I really liked the online videos. It was very handy to be able to pause them, replay,... allowing me to take very good notes and understand everything.*

- *I really think this is the way other courses should be given too, everything isvery clear and you can watch al the material again on blackboard. Listening to someone talking to you is always better for my understanding than reading a slide with words and pictures on it.*
- *I really appreciated the interaction/jokes of the teacher! In the beginning I really didn't like the throwable mic (I even was afraid of it), but the more I attended the lectures, the more I saw how useful that thing is!*
- *Mock exams where really helpful to see how we will be assessed at the exam*
- *I appreciated the combination of video preparation before lectures and the very clear course layout as given in the planning table (eg with learning units and recommended problems and coz: great way of learning!)*

Overall, the positive comments indicated that the blended aspects were well received and appreciated by a number of students. However, there were also a number of more negative comments. Amongst these comments:

- *The videos are way less effective than a traditional lecture and instead of being the primary source of learning it would be better if they were supplementary to the lectures.*
- *Although I think "flipping the classroom" is an interesting new approach to teaching, this was definitely not the right way. The videos were really clear, although maybe a bit slow sometimes, but the lectures were almost useless. I'm pretty confident about the skill level of the lecturers I had, but the organization of the course made the lectures almost completely unnecessary, which caused that I didn't go to almost any of the lectures.*
- *I strongly do not agree with the idea of throwing the microphone and get people participated in the class where there are hundreds of people in space. Before any content was covered in off-line lecture, I was prepared with watching every single video, attempting all the exercises and the COZ problems, but still I was always stressed whenever the lecturer was throwing the microphone at students.*
- *Personally would have preferred regular lectures over watching the videos in advance.*
- *Please stop with your movies, you're not an entertainer but a professor. We come to university to have lectures instead of watching movies with a very low information density and lectures with only examples and online quizzes.*

Taking into account all of the comments, it is evident that a blended learning approach will not be successful at making all students happy. Indeed, it should not be a surprise that in a large class full of students with varying learning styles and needs that a perfect teaching approach does not exist. Despite this, the average response to the course was mostly positive, providing motivation to continue refining the approach.

5 CONCLUSIONS

An initiative to blend a 1st year Mechanics of Materials course to improve student success has been presented. The aim of applying a blended approach was to open up face-to-face time with students to application of knowledge and to link this with helping students identify and develop intrinsic motivating factors for their own learning. The first implementation of this approach was met with some successes and some failures, but overall the approach was seen as a positive improvement that will be further refined in the future.

6 ACKNOWLEDGMENTS

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