CAN DESIGN AND ANALYSIS BE EFFECTIVELY TAUGHT TOGETHER?

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ABSTRACT

This paper presents two major elements of a course redesign with the aim to strengthen the connection between engineering design and engineering analysis. The course, Aircraft Structural Design and Analysis, had previously been delivered with a heavy focus on mathematical analysis and solving complex problems. It was observed, however, that in later design projects within the curriculum, students were unable to apply these skills in a less constrained design context. To combat this, two-course elements were introduced. The first element was a design tutorial session that ran in parallel with the course and interfaced with real design activities being carried out within the AeroDelft Dream Team at Delft University of Technology. This session attempted to have students apply the skills they had learned in class to a less constrained design problem with more freedom than traditional practice problems, focusing on design thinking rather than reproducing an expected answer. The second element was a design-based final exam, where all of the questions within the exam were interconnected by a single design context. The first iteration of these design elements, including lessons learned and analysis of their impact on student success, will be presented within this paper.

KEYWORDS

Structural Analysis, Aircraft Design, Real World Learning, Integrated Learning, Course Evaluation, Standards: 4, 5, 6, 7, 8.

INTRODUCTION

Many lecturers in engineering often face the dilemma of how to teach design and analysis skills effectively and simultaneously for complex engineering disciplines. On the one hand, design requires a deep understanding of discipline-specific concepts, the meaning behind them, and realization that design-related decisions are more about compromise rather than correctness. Teaching design thus needs to emphasise decision making and justification. Analysis, on the other hand, requires a rigorous application of discipline-specific concepts to obtain answers to problems that can be assessed in terms of their correctness and sensibility. Teaching analysis thus needs to focus on precision and correctness. But how can we teach new concepts and ask on one hand for students to perform analyses to calculate precise correct answers we are looking for, yet on the other hand teach students that design does not have precise correct answers?

This is precisely the challenge faced within the 2nd year, 5 EC (= 140 h) bachelor course entitled *Aircraft Structural Analysis & Design* at the Faculty of Aerospace Engineering at Delft University of Technology. The course in its many previous forms followed a more analysis focused approach, relying on lengthy mathematical derivations of formulas that could be used in analyses that were then reinforced by numerous in-class and practice problems. Effectively, the course focused on analysis and expected students to absorb the concepts and be able to apply them on their own in a design setting. As a result, it was observed that students were incapable of applying their structural analysis skills in capstone design projects, more specifically the Bachelor final thesis design project, the Design/Synthesis Exercise, where the design problems were not formulated as questions with precise and correct answers. Secondly, the students perceived the course as abstract, difficult and not too relevant for the design work they had to carry out in the bachelor. As a result, the course is considered to be one of the hardest courses in the bachelor curriculum. In the past attempts have been made to make the course more accessible for students through computer-based homework introduced as early as 1990 and lab experiments to visualise the concepts (Saunders-Smits & de Vries, 2005). To address these issues, the course delivery was redesigned to place a larger emphasis on conceptual understanding and design, using the CDIO standards (Malmqvist et al. 2007) as its guide to activate students in their learning.

This paper reports on the course redesign, the lecturers' experiences during the running of the course, the opinion of the students on the new method and conclusions and reflections on the course with recommendations for further improvement.

Literature review on teaching structural design

Many engineering education educators agree that it is important to engage students with the material taught by using real-world examples (Malmqvist et al. 2007, Trevelyan 2016, Sheppard et al. 2009, and Goldberg & Somerville, 2014). At the same time, many lecturers find this daunting as they do not always have experience as a working engineer or are concerned that this will lower the level of the course by being "too applied" and not fundamental enough. There seems to be little faith by lecturers and the institutes they work at, in the ability of lifelong learning of their students to gain more knowledge independently, after having been taught the basic principles.

This is also very apparent in the field of structural mechanics. Within Europe, quite a few institutes advocate a traditional, extremely theoretical approach embedded into fundamental classical mechanics and the accompanying detailed mathematics. Typically, these courses are accompanied by laboratory exercises with all students carrying out the same measurements on the same experiments from year to year without any design freedom or connection to real life problems. Not surprising there is little literature available reporting on its successes. Other institutes choose a teaching approach that is closer to practice with example problems that resemble real structures and instead of repetitive experiments, the courses are accompanied or followed on by project-based design exercises with some design freedom and often involving practical skills and synthesizing mechanics with other courses such as reported by Crawley et al. (2005), Nengfu et al (2009) and Peng Lin et al. (2006) The authors' own department is also currently using this approach in their bachelor following the CDIO principles (Saunders-Smits et al. 2012). Although there is nothing wrong with this approach, in the act this is exactly the sort of projects that should be encouraged, they do have one downside. Due to the emphasis on synthesis, and practical and soft skills, there is often not enough room in these projects to truly carry out a detailed, realistic structural design of more complex structures such as ships, aircraft and launch vehicles, allowing students to really grasp structural design concepts in these fields. This is why two of the authors decided to introduce team-based design tutorials and a design-themed exam based on a real aircraft design project in their Aircraft Structural Analysis and Design course.

COURSE SET UP & EDUCATIONAL APPROACH

The course is run during a 7-week period with 6 weeks scheduled before the Christmas break and 1 week scheduled after in line with the uniform scheduling of the university. The final 3 h, written exam for the course is set some two weeks after the last week of lecturing. The learning objectives of the course are for a student to be able to:

- Calculate stresses/strains in thin-walled structures using:
- Engineering beam theory (bending and shear) and torsion theory (closed and open sections),
- Modify the above theories in the presence of redundancy and/or cutouts,
- Calculate displacements using: beam theory and energy methods (incl. Castigliano's 2nd theorem),
- Determine the buckling loads for simple structures such as beams and trusses,
- Determine buckling/crippling loads for stiffened panels,
- Design such structures by determining the geometry such that structure does not fail (thickness of skins under bending, shear and torsion; cross-sectional geometry of beams under compression)

The lecturers were interested in trying a new approach with an aim to engage students more and were inspired by the Conceive, Design, Implement and Operate principle. They felt that by introducing design as an activity during the course students would be more engaged with the material, but to avoid the design being just another set of calculations on paper, they also looked at a way to implement design by using a real-world example of an aircraft that is being designed by one of the Delft Dream teams[1] meaning the design would also have a real life purpose and thus enhancing engagement. The design part would not be made a mandatory activity, but the design theme would also be used in the assessment making this attractive for students who are intrinsically motivated for engineering and design as well as the students who are unfortunately still just grade-focused.

As a result, two new course elements were introduced in the academic year of 2018-2019 in an attempt to effectively embed design thinking, reflection, and decision making into the course Structural Analysis and Design: A Design Exercise and Design-themed Exam.

The overall organization of the course now consists of two, 2 h weekly large classroom lectures in a modern multiscreen lecture theater with the use of a digital Blackboard and powerpoint presentations and a one 2 h weekly design tutorial on a Friday afternoon in the large dedicated groupwork classroom in Pulse, the recently opened modern learning centre at Delft University of Technology[2] (see Figures 1 & 2). Students are given (voluntary) homework to prepare for the design tutorial. To assist students in keeping up with the material 3 intermediate tests are administered allowing students to gain up to 60% of their final grade with the final exam counting for 40% instead of the final exam counting for the full 100%. The tests are optional, and the highest grade (intermediate test and final exam or just final exam) counts. This is done

[1] https://www.tudelft.nl/en/d-dream/
[2] For a virtual tour of Pulse see: https://nmc360.tudelft.nl/vt_pulse/

to allow for students who fall ill or who are retaking the course as they did not pass it in previous years.

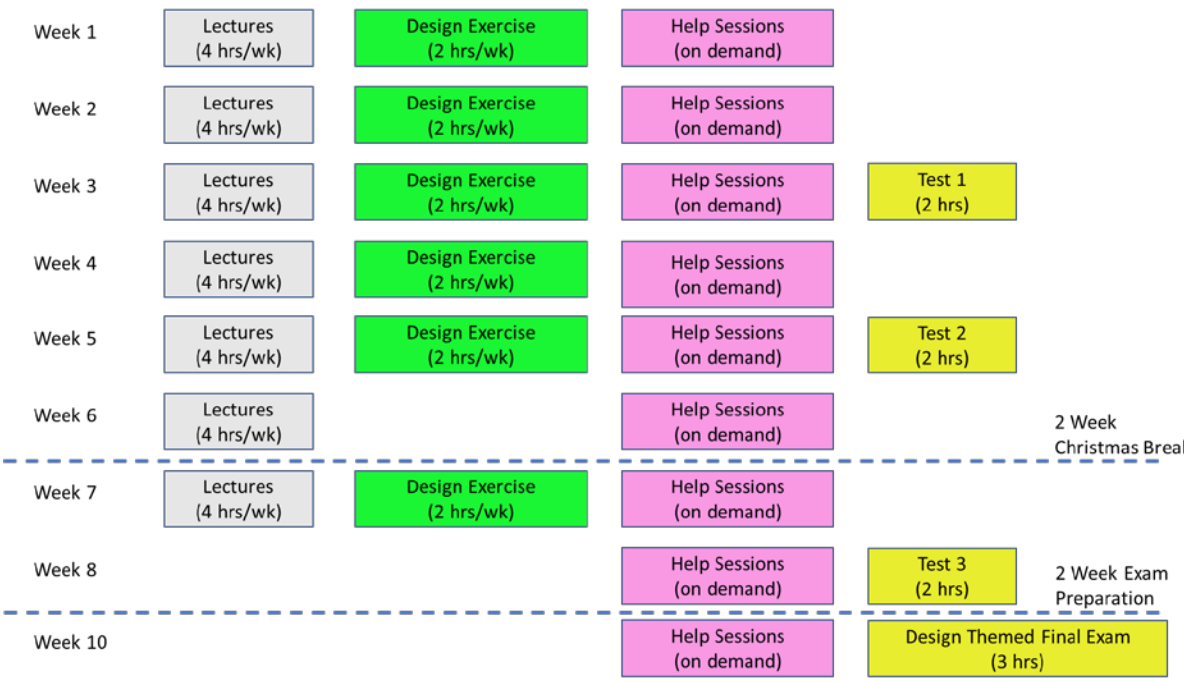

Figure 1: Organization of learning/assessment activities and related student time commitment for the entire Structural Analysis and Design Course.

The new elements include a new unifying design exercise which aimed to tie all analysis skills taught in the course to a real and relevant design problem, and a design-theme interlaced through the course final exam. Each of these elements will be described below in terms of their intended execution with a critical reflection on their success.

Design exercise

When designing technical artefacts, like aircraft and spacecraft, a considerable part of the time is spent on the structural design. The design process often starts with the use of statistical methods. This leads to a so-called Class I or conceptual design (Raymer, 2018; Roskam, 2004; Torenbeek, 1988). These methods give a first estimate of not only the performance but also the mass of the object. In the next steps of the design process, the object is detailed more and more. This includes designing a suitable structure and detailing it step by step. This starts with determining the loads on the structure, then designing the structural setup and in the end all the way to the bolts and nuts including determining the mass of the structure. In the framework of the course Structural Analysis and Design, six design tutorials have been incorporated to mimic this design process. The students were given a Class I design of an aircraft developed within the Dream team "Project Phoenix" (http://www.aerodelft.nl/project-phoenix.html) and were asked to make a structural design of the wing.

The topics addressed in the six design tutorials were:

1. Loading diagrams
2. Preliminary design for bending and torsion
3. Preliminary including shear

4. Structural idealizations
5. Stiffened skin panels
6. Holes and cut-outs

The topics of the design tutorial kept track of the topics discussed during the lectures. We framed the situation such that the students were put in the position of structural design engineer within the Project Phoenix “company” and made responsible for the structural design of the aircraft.

The intent of the tutorials was to give students complete design freedom and the chance to demonstrate the skills they acquired so far. However, after a couple of weeks, it was noticed that students struggled with this freedom. They felt insecure, were wondering what the “right solution” to the problem was and as a consequence of that felt lost or disinterested, and attendance dropped.

This observation led the lecturers to the conclusion that the students needed more guidance. After three of the six tutorials, the set up was changed. We framed this as a ‘hostile take-over’ of the company and converted the design assignments into more concrete design tasks for the remainder of the tutorials. The students appreciated this change. It gave them the feeling the tasks had become more manageable for them.

Figure 2: Students discussing the size of an inspection hole in the wing (left) and the dedicated lecture rooms for the design tutorials (right).

Facilities used
The tutorials were organized in a dedicated lecture room. This room has a set-up in which the students can find tables to sit at four ascending levels. Every level offers four project tables with eight seats each. Because of the ascending levels, the students all have a good view of the lecturer, the smart board and the presentation screens. The four levels are set up such that the accessibility for the lecturer is excellent. This allows a good interaction between the lecturer and the teams of students. Every table is equipped with power outlets for the student’s laptop computers and a whiteboard such that the students can make sketches of their designs.

The students were asked to form their own design teams. Every tutorial started with a short introduction of the assignment of the day by the lecturers. After that, the students started working on the assignment. The lecturers walked around for one-on-one tutoring. Every now and then some common issues were addressed for the whole of the group.

On the web-based learning management system “Brightspace” that is available for all courses within TU Delft, a forum was created where the students could share and discuss their design solutions.

Design-themed exam

Traditional final exams for most engineering analysis course comprise of multiple questions designed to test individual learning objectives or skills taught within the course. These questions are typically designed to be completely self-contained questions that are not dependent on one another. There is good reason to have this independence between questions, as it is desirable to provide students with the opportunity to demonstrate their mastery of different skills without a lower mastery of one having a negative impact on the assessment of mastery in another. However, from an extreme point of view, this approach can diminish the necessary interconnection of these skills in a real engineering context – effectively cleansing the final assessment of the desired thinking for a CDIO mindset.

The goal of the *Design-themed exam* was to address the lack of interconnection between skills from a design context while still maintaining the independent assessment of the mastery of individual skills. Although these goals may seem to be in opposition with each other, this was achieved by utilizing the following elements within the exam:

- Providing a design case that provides a unifying context in which all individual questions relate to;
- Organizing individual questions in a logical order mimicking a typical design process;
- Utilizing *design iterations* and *working in engineering teams* as mechanisms to minimize the dependence between the assessment of mastery of individual skills;
- Adding reasoning-based sub-questions to allow students to demonstrate their understanding of the interconnection of individual concepts.

Each of these elements will be briefly summarized in the remainder of this section.

Contextual Design Case

Critical reflection on the meaning and impact of a result calculated by a student can only be achieved if there is a clear context for that result. This was the driving principle behind establishing a clear, yet simple, design context for all analysis-based questions within the exam. An example of such a case used within the 2017/18 final exam is provided in Figure 3.

Design Case Description:
A European consortium is designing a commercial tiltrotor aircraft that is being designed to compete in the regional aircraft market (concept image is shown on the right). You are part of a design team responsible for the design and sizing of the wing structure. All questions in this exam will relate to this design activity.

For all questions, when needed, you can assume the following material properties:

$$E = 70GPa \qquad G = 30GPa \qquad \nu = 0.33$$

$$\sigma_y = 482MPa \quad \sigma_{ult} = 538MPa \quad \tau_y = 245MPa \quad \tau_{ult} = 310MPa$$

Figure 3. Example of an exam design case description

Four key elements can be observed in this description:

1. Visualization of the overall design concept to trigger the students' ability to see how elements of their analysis fit within an overall aerospace system;
2. Concise and relatable context with respect to desired functionality;
3. Defined role/responsibility for engineering team (i.e.: wing structural sizing);
4. Baseline set of material properties to be considered in all analyses.

Question Sequence Mimicking a Design Process

With a design context set, a series of questions were presented in an order that would be logical in terms of a design process. Specific elements of this are common between exams; however, depending on the concepts being tested and the particular scope of the *Contextual Design Case*, adaptations are made on a per-exam basis. The general process flow is summarized in Figure 4 by the blue arrows. All exams started with an analysis of the internal loading state, reinforcing skills from a prerequisite course and their connection to the context of the present course. Specific skills were then tested in the main areas of modelling and idealizing structural concepts; calculating relevant internal stresses using those models; as well as a select number of detailed analysis methods covered in the course, such as buckling & crippling analysis, energy methods, and design of cut-outs. This progression allowed the concepts from earlier questions to easily be connected to later questions using reason-based questions which will be discussed later.

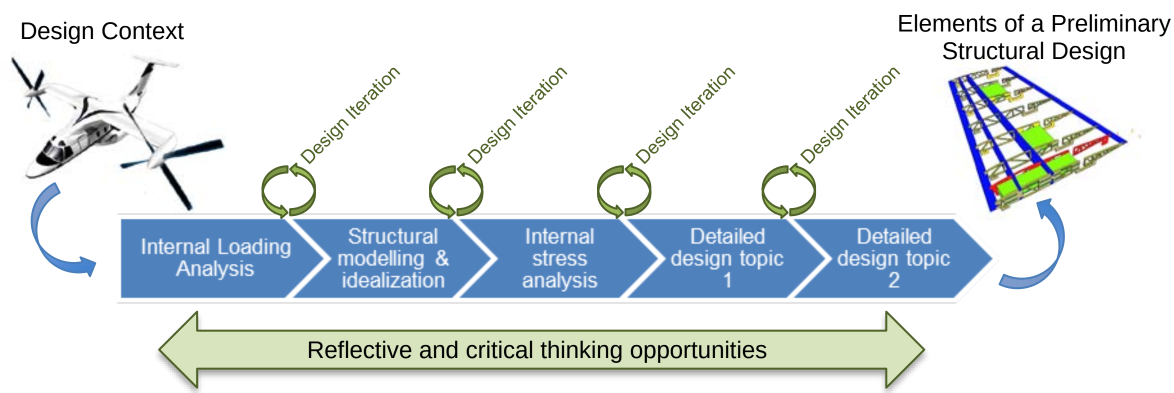

Figure 4. Overview of exam setup

Team-based Design Iterations

In order to mitigate the risk of early mistakes or poor mastery of specific skills early in the exam from causing a cascade negative effect on the overall exam, the concept of an engineering team-based design iterations were used to provide common intermediate design states within the exam for the students to work from. For example, after the student completed the first question analyzing the internal loading, follow-up questions requiring an internal loading to work from would provide an updated critical load state to analyze, stating that *this new loading state had been obtained by a team member after a design iteration*. The effect of this was threefold:

- it reinforced the iterative nature of early structural analysis and design,
- it provided assurance to the student that early mistakes would not adversely affect the entire exam,
- and it provided an opportunity for students to reflect on their earlier answers and potentially identify their own errors.

This last point requires further explanation. When introducing new values for variable updated through a design iteration, care was taken to provide updated values that were consistent with the design context. As a result, the updated values could be expected to be within the same order of magnitude as the original values calculated by students or related to their original answer through a described change in the design iteration. This addressed a skill that was found to be lacking in previous exams – students were rarely reflecting on their answer and how much sense it made. By providing the updated values, it was observed that students would often be triggered if the newly provided values were substantially different than their original values.

Reason-based Sub-questions

Sub-questions that required reasoning, rather than straight calculation, were also included to reinforce interconnections within the overall exam. In this way, we could ask questions about the impact of later detailed design analysis/decisions on the work performed earlier in the test or on forward-looking design decisions. For example, early structural models for which they performed calculations on earlier in the test could be revisited by asking the impact of adding several stiffeners to the model based on a detailed buckling analysis performed later in the exam. Rather than having the student perform the new calculations, they were asked to reflect on the expected impact of those changes on their earlier analysis and whether that earlier analysis would now be conservative or non-conservative. This critical reflection is a key part of the design process where earlier analysis needs to be evaluated in terms of whether they are *right enough* for the needs of the design.

COURSE REPORT AND EVALUATION

Course report

The course started with well over 300 students attending the first lectures, which quickly dropped down to a steady cohort of 150 – 200 students. This is not surprising as many students “check out” the course at the first lecture and then decide whether to take the course and whether to follow the live lectures or the recorded lectures. The lecturers heavily promoted the introduction of the new design tutorial in the first lecture and as a result, over 250 students turned up divided over two sessions for the first tutorial. This number also rapidly dropped off to only 70 students showing up for the last session. To assist students with questions on the homework problems and intermediate test preparations, daily help sessions were organized at lunchtime and manned by experienced teaching assistants. Typically, 5 - 10 students attended daily with that amount tripling on the days before the partial tests and exams. The partial tests were more popular with 456 students taking part in the first session and 406 and 303 students taking part in the second and third test respectively. A total of 422 students took part in the regular exam in January of 2019.

The drop off in student activity may seem drastic but is in-line with normal student behavior at the institute. Students are held responsible for their own planning and choices and there are no far-reaching consequences for them to drop out of courses or to not fully participate in a class. Mandatory attendance is not promoted for non-lab or project-based courses. As a result, students make their own choices and accept the inevitable delay in their study progress.

Course Evaluation Set Up

To evaluate the intervention of introducing design tutorials and a design themed exam to the course a questionnaire was handed out during the last lecture, the last design tutorial and the exam. The focus in the questionnaire was in particular on the learning activities offered to the students, in particular, the design tutorials. The design theme of the exam was not evaluated. Participation was voluntary and all data analysis was carried out by a staff member who was not part of the course to ensure impartiality. Ethical permission from the university's Human Research Ethics Committee was sought and given. A total of 83 students responded of which 8 chose to not have their opinion linked to their results.

Course Participation

Students were asked about their participation in the various offerings of the course. The results are listed in table 1 below. Participation in the partial tests is the highest, followed by lectures. The design tutorials are also regularly attended by more than half the respondents. However, 29 respondents did not take part in the exam. Reasons for not taking part in the exam have not been investigated.

Table 1. Self-reported participation percentages in the course.

Lectures	N = 83	Design Tutorials	N= 83	Help Sessions	N = 81	Partial Tests	N = 81
< 3	3.6%	None	15.7%	None	69.1%	None	1.2%
4-7	9.6%	1-3	24.1%	Before exam only	6.2%	1	2.4%
8-11	16.9%	4-5	22.9%	Before tests only	22.2%	2	12.0%
12-14	69.9%	All 6	37.3%	All sessions	2.5%	All 3	81.9%

In a number of open questions, students were asked for their reason for not participating in the lectures, design tutorials or help sessions. Most predominant reasons given for not attending lectures were other obligations including work, clashes with other courses and bad planning.

For design tutorials, the reasons given for non-attendance were other priorities, not useful, did not like set up or being too far behind. With regard to the help sessions, most students indicated they did not need them, and a small number of students cited other obligations or unawareness of the existence of help sessions. Finally, when it came to reasons for not or no longer participating in the partial tests the predominant reasons given were: lack of confidence, scheduling conflicts and illness.

Evaluation of the design tutorials

When asked why they attended the design tutorials, most students indicated that saw it as an opportunity to learn more about designing, practice the material and prepare for the exam. They also indicated they attended because they found the design tutorials useful, preparing for their professional future and fun. When asked what they liked the most about the design tutorials the students indicated they really liked the application of the material to a real-life design problem, exchanging either with peers and working in groups, the design freedom and the more structured approach after the 'hostile takeover'. Finally, when asked what students thought that needed to be improved about the design tutorials, they overwhelmingly indicated that they would prefer to have more guidance and less freedom at the beginning with increasing design freedom as the weeks go on, as opposed to the way the tutorials were organized this time. Students also would like more support to be available during the session and work out a better way to create groups. Some students also expressed the desire to understand better how all the tasks fit together.

Relation between course results and participation in design tutorials

The results, as listed in table 2, appear to show that the students who attend more than half the tutorials appear to do better on average on the partial tests and the exam compared to students who attended less than half. They also do better than the total student population. A Pearson's Chi-squared test was carried out to see if a significant relationship exists between passing the course and attending more than half the tutorials. It was found that $\chi 2(1) = 4{,}405, p < 0.05$, which means a significant relationship exists. The odd ratio was subsequently calculated and this showed that students who attend more than half of the design tutorials are 3.6 times more likely to pass the course than those do not.

Table 2. Mean test and exam scores compared between different groups of students. Note: A 10-point scale is used and a passing grade constitutes a grade of 6.0 or higher.

	Test 1		Test 2		Test 3		Exam		Final grade	
	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n
Respondents that attended < 4 tutorials	7.0	22	6.4	17	4.7	13	4.4	19	5.0	19
Respondents that attended 4 or more tutorials	7.3	43	7.3	27	6.1	27	5.5	28	6.4	28
All students	6.6	456	6.4	406	5.2	303	5.1	422	5.2	422

REFLECTION & CONCLUSIONS

As a general whole the course ran well although the lecturers did experience some logistical hiccups in the process. With a large number of students putting off this course or having to re-sit this course and no mandatory enrolment system present, lecturers are confronted with an unknown quantity of students leaving them with guestimates as to how many students to expect and to design the course for. This also affects the quality of the scheduling and allocation of lecture theaters. During the first lecture, the theatre was too small, and this may have contributed to students deciding to not follow the course or only follow it via recorded lectures which requires self-discipline and may lead to students dropping the course. The design exercise attendance was also affected by the availability and size of the theatre, the initial large design freedom and the unwillingness of students to work with different students in each design session resulting in entire groups dropping out. The lecturers decided to address the freedom by staging a 'hostile take-over' but do feel that being confronted with a large design uncertainty is also a fact of practical engineering life students should learn to live with early on in their education.

Unfortunately, the logistical issues described above are not so easily solved in terms of the systems and procedures for enrolment currently in place within TU Delft. As a result, it will remain a risk for future iterations of the design exercise. One of the biggest impacts of these logistical problems was the sporadic makeup of the individual groups from week to week. This had a major impact on the continuity of activities throughout the year and was voiced as a demotivating factor in the exercise. Some students found themselves without any of their group members showing up in a given week, and thus either had to work on their own, or join another group whose design may have been quite different from the lone team member's. To address this in future iterations of this exercise, rather than allowing each group to build upon their own design throughout the whole course, groups will vote on the best concept/design development from all of the groups from that particular session to form the common basis for the beginning of the next design exercise. Additionally, to combat some of the students' feelings of not knowing where to start in their design, it is intended to align the exercise with a design and construction project from the 1st year of the bachelor program. In that project, students designed and constructed a metallic wingbox with a large number of restrictions. The design exercise will examine this wingbox design, but remove many of the constraints, introduce a change from metal to composite material, and require multiple load cases to be considered. It is hoped that this will provide some confidence and familiarity with the design, but provide ample opportunity for challenging their initial design decisions with the new theory and concepts learned within the course. As an added bonus, students will be provided the opportunity to build their design after the course and test it at the end of the year when the 1st year students test their metallic wingboxes.

It is also worth noting that the design exercise had a very positive effect on the AeroDelft student project. The student group experienced a large interest from students within our course in participating in the project. Many of them indicted that the design exercise made them aware of what could be actually accomplished with what they were learning in class and motivated them to seek out more opportunities to apply their knowledge.

The design-themed exam was a larger success. Students generally seemed to appreciate the interconnection between the questions in terms of critical reflection of their own answers. Some students did complain about the length of question descriptions as the additional context necessitated more information to be provided, so this aspect will be kept in mind in future exams to attempt to strike the right balance between facilitating and over-burdening the students. One idea for the next iteration of the course is to publish the design context that will be used on the exam one week prior to the exam. This may spark discussions amongst students about the context, possible relevant question types that could be asked in such a context, and may provide a motivating context for their studying.

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BIOGRAPHICAL INFORMATION

Calvin Rans is an Assistant Professor and Educational Fellow at the Faculty of Aerospace Engineering of TU Delft in the Netherlands. He is actively involved in teaching across numerous bachelor and master courses related to structural mechanics and design, is involved in the production and delivery of several online courses, and is an avid proponent of blended, open, and online education. In 2019, he was elected Docent van het Jaar (teacher of the year) for the entire Netherlands.

Joris Melkert is Senior Lecturer and Educational Fellow at the Faculty of Aerospace Engineering of TU Delft in the Netherlands. He lectures in Aircraft Design, Sustainability, Flight Mechanics, Air Breathing Propulsion, Aircraft Manufacturing, Structural Analysis and Entrepreneuring. Furthermore, he is the co-chair of the Advisory Council for Aeronautical Research in Europe (ACARE) Working Group 5 on Research and Education as well as the co-chair of ACARE Strategy and Implementation Board.

Gillian Saunders-Smits is Senior Lecturer and Passionate Engineering Education Researcher and Curriculum Developer at the Faculty of Aerospace Engineering of TU Delft in the Netherlands. She teaches Research Methodologies to all Master students, runs a MOOC on the Introduction to Aerospace Structures and Materials and has previously taught Mechanics, Flight mechanics, and Design Projects and has served as Project Education Coordinator in the Bachelor and Master Track Coordinator for Aerospace Structures and Materials track and was the initiator of the successful online education program at Aerospace Engineering. She has overseen many curriculum innovation projects, most recently the overhaul of the MSc. track in Aerospace Structures and Materials. She is currently the principal investigator for TU Delft in the European Erasmus+ PREFER project on the Professional Roles and Employability of Future Engineers and serves on the Steering Committee of the European Association of Engineering Education (SEFI).

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