Proof of competence - UTQ module 21

1 Course description

Course name, overview, and duration : This proof of competence concerns the course AE4T40 "Kite Power and Propulsion". This course targets the developments in the field of Airborne Wind Energy, which consists in harnessing wind energy at high altitudes, and focusses on kite power generation. The course is divided into twelve lectures of two lecture hours each and one mandatory homework assignment, followed by a written examination. Participation in a test of the kite power system at the test site (former airfield Valkenburg) is optional but recommended. Depending on availability, guest lectures are also incorporated into the regular lectures.

Short description : The lectures tackle both an overview of the kite-power technologies and an in-depth mathematical analysis of such systems. First, an historical perspective is given to the development of airborne wind energy. Second, mathematical models are derived to describe the dynamics of a kite power system considered as a rigid body. Finally, possible approaches for modelling inflatable (i.e. non-rigid) systems are outlined. The applicability of the theoretical concepts is taught through practical assignments, laboratory/on-site visits, and guest lectures from industrial partners.

Place in the curriculum, credits, loads, and feasibility : The course is open to any MSc student. It is given in the Faculty of Aerospace Engineering (Master Aerospace Engineering), and has a work load of 3 ECTS. The course is deemed to be feasible in that the students should have received the adequate knowledge prior to entering the course. I verify the good adequacy and connection with other courses as described below.

Relation to other courses and ensuring good connections : The course is related to the MSc courses on Wind Power (AE4W20) and Fluid-structure Interaction (AE4117). The former is given by multiple colleagues working in my group, while the latter is organised by one of my colleagues in my department. I closely collaborate with the coordinators of these courses. I therefore have the opportunity to regularly discuss our course materials, in order to continuously ensure good adequacy between the courses. I also compare the various course materials on Blackboard, in order to ensure good connections between the various topics. In particular, comparisons between kite power systems and conventional wind turbines are made throughout my course, for example, in terms of power generated. Concepts of velocity vectors and velocity triangles, which are taught at the BSc level, are also revised and used in my course. In this context, the students' entry level is detailed in the next section.

Relation to exit qualifications : The course contributes to the exit qualification of having a broad and profound knowledge of Engineering, with the capability to apply this knowledge at an advanced level in the variant-related discipline. It also contributes to gaining a broad and profound scientific and technical knowledge of the track related discipline ; and the skills to use this knowledge effectively. Through assignments, the students apply this knowledge for analysing, modelling, simulating, designing and performing research with respect to innovative systems (i.e. kites), with an appreciation of different application areas (i.e. energy generation, ship propulsion). Furthermore, these assignments train the students to independently solve technological problems in a systematic way involving problem analysis, formulating sub-problems and providing innovative technical solutions, also in new and unfamiliar situations. They also ensure that the students are capable to effectively communicate their knowledge (including presenting and reporting in English), to both professionals and non-specialised public. As aforementioned, the students are advised to take part in the testing of TU Delft's prototype of kite power system. This gives the students the opportunity to interact effectively with specialists (PhD students, staff) and taking initiatives where necessary. This also stimulates the students to reflect on the technological, ethical and societal impact of one's work, and to take responsibility with regard to sustainability, economy and social welfare.

My role and others involved : My responsibility in this course is to contribute to the topics on the modelling of fluid-structure interactions for kite power systems. The course is lead by Dr Roland Schmehl (Associate Professor). My teaching role is limited at present because I started as an Assistant Professor last October, i.e. in the course of the semester. At the moment, I am involved in supervising assignments but have not started teaching in class. I will probably contribute more actively to the teaching activities from next year (to be confirmed in the upcoming R&D meeting). My collaboration with the colleagues is achieved through the following activities : (i) I regularly meet with Dr Schmehl to organise the teaching activities and assignments, and discuss feedback to give to the students, (ii) I share documents about the course via Blackboard, (iii) I organise regular joint meetings with the MSc students that conduct a project as part of the course, (iv) I participate in the project defenses, (v) I also meet with other colleagues responsible for connected courses (Wind Power, Fluid-Structure Interaction) in order to coordinate the teaching materials.

2 Students' entry level

Consideration of entry levels : This course requires to have completed a BSc. In order to ensure good adequacy with the students' previous knowledge, I consult the materials of the relevant BSc prerequisite via Blackboard. If deemed necessary, I also organise meetings with the course coordinators to ensure consistency between the courses. The prerequisites are available to the students in the course description. Importantly, the first lesson starts with an overview of the course prerequisites and associated learning objectives, so that the students know what is expected from them and where they stand. Links to relevant materials (online resources e.g. khanacademy.org, library books) are further given.

Actions taken in case of lack in required level : Self-scoring tests are posted on Blackboard, so that the students know where they stand compared to the required entry level. It is therefore the student's responsibility to revise the topics in which they lack knowledge. As aforementioned, I provide them with the relevant materials to do so. These materials include exercises with solutions, so that the students can monitor their progress during their self-study. Additionally, if the students have questions related to this material, they can come and ask specific questions during the course break or at certain times during the week.

3 Learning objectives

The current study goals for the course are the following.

"Give an overview of developments in kite technology, develop mathematical models for kites and design kite systems for industrial applications like ship propulsion and generation of energy."

I decided to rewrite these learning objectives in order to use verbs that describe **observable behaviour**. Also, I found that it was clearer to split the goals into distinct categories (bullet points), so that the students can relate the objectives to the various topics taught. The new learning objectives (LO) are :

LO 1 : to be able to enumerate, characterise, and compare the different types of kite technologies used for propulsion and energy generation,

LO 2 : to be able to derive, discretise, and numerically implement mathematical models that describe the behaviour of a kite system,

LO 3 : to be able to identify and quantify the parameters used to design a kite system for industrial applications.

I received good feedback about these learning objectives. It was suggested to me that I could give a bit more details, for example, about the parameters to quantify (LO 3). However, we also discussed during the module that there is no need to be too specific, since the students might not be aware of all the terminology before attending the course. I therefore decided to leave any specific terminology out of the learning objectives.

4 Constructive alignment

The constructive alignment table associated to the learning objectives is shown on the next page. Particular attention is given to alternate the type of teaching and learning activities. Therefore, for each learning objective, the students will learn by repetition, building correct fundamentals, and training in authentic environments. This diversification also aims at targeting various types of learners, as typically encountered in a classroom. I generally received good feedback about the initial version of the table. I however modified the following aspects after feedback :

- I incorporated feedback as part of my teaching and learning activities. In particular, I use it together with live discussions and questions in the classroom. This improves the student's learning, prior to doing the assignment on modelling traction kites in 3D (see table). Regular feedback during the assignment is also taken into consideration.
- I clarified that the course solely involves one group project. However, this project covers LO 2 and LO 3.
- Finally, I was told that the number of assessment methods (exam, assignment report, and project presentation) can be time-consuming. This is however a MSc course, with a relatively small number of students. Additionally, the groups used for the assignments can be flexible in size, in order to reduce my work load during the assessment. Support from colleagues is also available.

The concepts of constructive alignment and active teaching helped me to improve the structure of my course, in particular with respect to the various teaching activities to perform. I also found interesting the discussion about *active teaching* versus *active teaching and learning*. In my previous teaching experience (i.e. prior to coming to TU Delft), I was generally active and relied on visual means to explain physical concepts in class. This module taught me that it is also important to focus on what the students are actually doing during the teaching process. I will now take that into account in my teaching by adding one-to-one interactions, group discussions, and group feedback during the course (as described in the constructive alignment table).

Objectives	Teaching and learning activities	Assessment	Explanation of the alignment
LO 1 : enumerate, characterise, and compare	a) Discuss in small groups potential kite systems for propulsion and energy generation. b) Lecture about the various technologies, including pros & cons.	Exam question. For a given kite technology, describe the system and give pros/cons w/r to power production. Put in perspective with the other technologies available.	The students have to learn about the existing technologies. This knowledge is qualitatively. Therefore, the objectives are achieved by giving a lecture and making the students reflect on the topic in small groups. The qualitative knowledge can be well assessed by an open exam question, in which they need to discuss a given technology. The group discussions also stimulate the students from the first lesson.
LO 2 : derive, discretise, and implement	a) Prior reading and lecture about the various parameters of a kite system and the velocity vectors. b) Group discussion about the important factors for effective power generation. c) Lecture about the derivation of a single point-mass model in 2D. d) Discussions and live questions to the students on what is necessary to derive the model for a traction kite in 3D. e) Group feedback to the students. f) Lecture about the numerical modelling of fluid-structure interaction for kites. g) Group project about the development of numerical models for kites.	- Exam question. Derive a mathematical model for a given kite system. Discretise the model in order to solve it numerically. Implement a short numerical program. - Regular feedback on the assignments and group project. - Individual assignment for derivating an analytical model for a traction kite. Report assessment. - Report, presentation, and demonstration for the group project.	By alternating the methods of active teaching, the students will repeat the new knowledge through various activities during the course and assignments. The theory about model parameters and discretisation is well learned through self-study and lectures. However, deriving a model is time-consuming. This is why the actual objective will be assessed through an assignment. The procedure to follow in the assignment is discussed in class and feedback is given to the students prior to handing over the report. The students are thus prepared for the assignments through group discussions and feedback in the classroom. The student will finally train team work on a structured exercise, hence benefiting from peer feedback.
LO 3 : identify and quantify	a) Lecture about the pumping cycle and kite trajectory. b) Group discussion on the interpretation of power diagrams for a kite system and the parameters influencing the power output. c) Lecture on power outputs. d) Continuation of the aforementioned group project to design a kite power system in a given environment. e) Visit of the kite power laboratory.	- Exam question. Determine the power diagram of a given kite system. Assess and quantify the parameters that should be modified to increase the power output. - Regular feedback on the assignments and group project. - Report, presentation, and demonstration for the group project.	The learning objectives require to develop quantitative knowledge of kites and apply it. Therefore, the appropriate method is to discuss the lecture materials (including real data) and design a system in groups. The group project will motivate the students to come up with the "best" kite system. They will receive regular feedback on their progress. Importantly, they will see a working prototype of kite power system and discuss to PhD students working in this area. This will help them to develop quantification/design skills. The theoretical knowledge is well assessed through an exam question and a report. However, the practical aspects of the learning objectives are best assessed through a live demonstration of the project outcome. An oral presentation during the demonstration will also train the communication skills of the students. The best project outcome could further be used for an outreach event during the university open days.

5 Description of one active teaching and learning activity

This section describes the active teaching and learning activity LO 2d : "Discussions and live questions to the students on what is necessary to derive the model for a traction kite in 3D". It consists in first a series of questions that the students have to answer both individually and in small groups, in order to check whether they understand the theoretical concepts correctly. A typical slide showed during the activity is reproduced in Fig. 1 and outlines the questions to be discussed in class. The activity forces the students to actively think and discuss about the concepts that they learned throughout the course, in the following way.

Q1 : To answer the first question, the students have to **repeat** the set of assumptions that they learned during the previous activities. This trains the students to **build correct fundamentals** for the rest of the model derivation.

Q2 : The second question involves multiple activities. First, the students have to revise two theories that they have previously learned by **deriving** them and **reflecting** on how they compare. In particular, they need to identify for which set of parameters are the two theories identical. Finally, they need to quantify these parameters. The students will therefore actively work with the course content, and importantly, reflect on topics that were taught during different lessons.

Q3 : The third question requires the students to understand the main differences between power generation and ship traction using a kite system. Again, this involves knowledge that was taught in various lessons throughout the course. Power generation is ultimately what is important for a kite system. This topic therefore helps the students to think about **practical aspects** of such systems, and how to affect/optimise them.

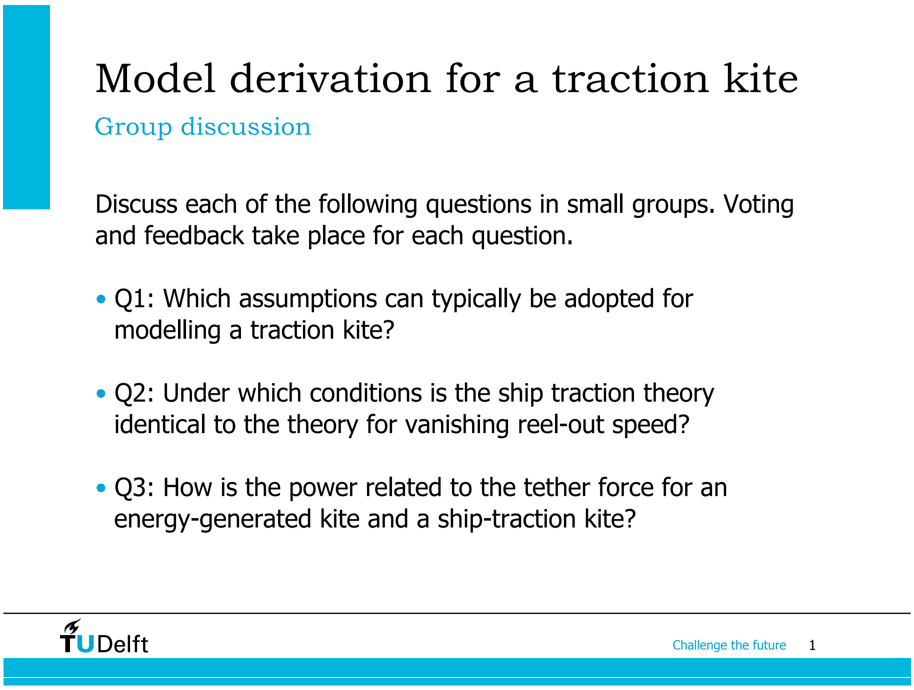

FIGURE 1 – Example of slide given for the active teaching and learning activity LO 2d.

The students have a limited amount of time to answer the questions. After each question, voting is used to collect the answers. Depending on the rate of success, additional sub-questions can be introduced to clarify certain aspects of the course. I also divide the students in groups to provide group feedback on the various answers. After this activity, an assignment to be achieved at home is given to the students.

6 Link between the course and the future professional practice of the students and scientific research

Connections between the course and both the future professional practice of the students and scientific research are made in the following ways.

1. Guest lectures from people working in industry and academia. Whenever possible, guest lectures are incorporated into the regular lectures. This year's lecturers include the CEO of SkySails, which develops kite systems for ship propulsion, and a research group leader from Brazil where wind energy becomes increasingly important.

2. Visit to the kite power laboratory at TU Delft. As part of the course, a visit to the university laboratory is organised. This enables the students to :
   - see all the components of a kite power system, as learned during the course,
   - discover the experimental facilities used in the field, and also, learn about the scientific research in the area,
   - talk to PhD students working in the kite power group, and thus, informally gather information about up-to-date scientific research in the field and the researcher career.

3. Participation in an onsite demonstration of the university kite-power system. This activity is optional but highly recommended, so that the students can see a full-scale kite power system, its maneuvering and the procedure required for launching and retrieval. This gives a highly practical insight into the theoretical concepts taught in class.

4. References to scientific papers. As part of the active teaching and learning, the students have to read a scientific paper (Loyd, Crosswind kite power, J. Energy 4(3), 1980). The theory outlined in the paper is part of the course content. Additional references are also given to the students for further reading.

5. Interactions with PhD students and staff. As part of the course assignments, the students have the additional opportunity to ask questions and receive feedback from PhD students and staff working in the kite power group. This contributes to improving the students' learning and gives further insight in the scientific activities in this field.

7 Conclusion

In module 21, I learned mostly about active teaching and learning, what happens in the brain when we learn, and Bloom's taxonomy with the distinction between lower-order and higher-order thinking skills. I was already familiar with the concept of constructive alignment and the writing of learning objectives, because of another training course I attended abroad as part of my previous academic position.

Following my previous teaching experiences, I know that : (i) I am active when teaching, and (ii) I use visual means or everyday examples to illustrate key theoretical concepts. However, the module helped me to realise that this is not equivalent to an active learning and teaching method. I learned that it is key to always ask myself *"what are the students doing ?"* in order to develop an efficient teaching method. This is definetely something I will use to improve my teaching in the future. The module also taught me the three key elements in the process of learning, that is repetition, building correct fundamentals, and training in authentic environments. I will organise and write my teaching material accordingly, in order to optimise the learning process of the students. Finally, I found useful to discuss with the other attendees and gain from their experiences, for example, on how to motivate the students and students assessment.

In summary, I am very glad to have attended module 21. I believe that it gave me good skills to improve my teaching, in particular in terms of getting the students active throughout the course. It also provides a good source of information in case a new situation happens during my teaching. I look forward to attending the other modules.