The First Steps towards an Online Master in Aerospace Engineering

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INTRODUCTION

Online education is the trending topic in the world of teaching at the moment. Education is experiencing a paradigm shift from classroom learning to an increasing form of "guerrilla learning", students actively seeking knowledge from whichever

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source they can obtain their knowledge from in a form or shape that they prefer to learn in [1]. The seemingly endless possibilities of the World Wide Web have played an important role in enabling guerrilla learners to find the knowledge that they seek. In order for institutes of Higher Education to maintain their position as providers of excellent higher learning they must also make a transition from just providing to "classroom learners" to anyplace, anytime, anywhere students.

As a result many developments have taken place over the last decade. Most universities started by recording their lectures for their own students and then moved on to offering free educational content using OpenCourseWare initiatives, offering online lectures as podcasts and, according to the latest trend, to running Massive Online Open Courses (MOOCs) allowing students to even get some sort of certificate of completion. The logical next step that has already taken off big time in Computer Sciences, Law and Humanities with the likes of Kaplan University and the University of Phoenix is the offering of complete online degrees. So far in Engineering Education this is still relatively unchartered territory. It is most likely that this stems from the different type of knowledge as well as the practical skills required in Engineering Education [2] which makes going online a steeper challenge.

Delft University of Technology (TU Delft) has so far followed the path described above by recording its lectures, publishing them on ITunes and being a very active member in the OpenCourseWare [3] consortium. It is about to embark onto the next two steps: (i) Starting September 2013 TU Delft will offer three MOOCs and (ii) TU Delft has started the development of online accredited MSc Programmes in Water Management, Engineering and Policy Analysis and Aerospace Engineering, more specifically in Aerospace Structures and Computational Mechanics. More information on all of TU Delft's online activities is available from www.tudelft.nl/en/study/online-education.

This paper describes the experiences of the research group of Aerospace Structures and Computational Mechanics (ASCM) in their first steps towards an online Master. The next section gives a background behind the online MSc initiative at TU Delft followed by a short description of the organisational set up. The second section tells you what educational online formats have been selected in the design of the first online courses and the third section shares the experiences of the pilots as run in the academic year 2012/2013 as well as the outcome of student evaluations. Section 4 deals with the plans for 2013/2014, and the paper is concluded with lessons learned and recommendations for others who want to develop similar initiatives to benefit from.

1   THE ONLINE MSC INITIATIVE AT TUDELFT

1.1 Background

In the spring of 2012 TU Delft put out a tender for all its MSc programmes to develop online MSc courses. Out of the many entries the three above-mentioned MSc programmes were selected and each awarded €100 000 to turn some of their existing MSc courses into online MSc courses. In return the courses that were run online would also have to be made available in TUDelft's OpenCourseWare initiative. A prerequisite was that only use of the current educational ICT facilities should be made. Next to that they were offered full support from all the administrative bodies within the university from the didactical service unit, registration, legal services, marketing department and of course ICT and the New Media Centre.

The research group ASCM of the Faculty of Aerospace Engineering has a long running tradition of educational innovation [4,5,6,7] and excellence. Over the past 4

years two of its lecturers have been awarded the coveted Aerospace Teacher of the Year Award. Next to that among its staff it counts some of the world's leading experts in lightweight (composite) structures and design optimization, making them highly sought after guest lecturers. As members within the group often receive requests from industry and outside institutions for workshops and short courses the group felt there was a definite interest and market for its accredited courses both in the Netherlands as well as in Europe and beyond. With this in mind the group selected courses they felt would meet the need of life-long learners who would like to stay up-to-date in the fast changing field of aerospace structures due to the current widespread mainstream implementation of composite structures in Aerospace such as for instance in the Airbus A350 and the Boeing 787.

1.2 Organisational Challenges

When starting such a new initiative it became very clear from the start that it was important to involve all the different parts of the university support system. For instance although at a faculty level there were local registration systems for students only registering for single courses now a university wide system had to be designed and implemented which involved close cooperation from the educational administrators office, the admissions office, legal services, finance and ICT. Another challenge for instance, is the recognition of the certificates awarded. This also meant external parties had to be involved such as the Department of Education, Culture and Science, the Association of Universities in the Netherlands and the accreditation organizations. To ensure all parties within the universities were sufficiently informed and aware of expectations, a university wide workshop involving all directors of the university's service departments, deans, student representatives and involved project leaders was held to increase awareness and cooperation.

1.3 Selected MSc courses and its target audience

As stated before the ASCM group identified a niche market in which they felt their courses would be welcomed with open arms. The courses selected for online development are primarily aimed at working industry professionals who function at a BSc/BEng level and above, who are looking at updating their existing knowledge, increasing their expertise or their education level. A second identified market consists of MSc students from other universities across the globe that are interested in the courses offered to serve as an external elective in their own MSc curriculum. Based on the identified market the following six courses have been selected to be developed as an online MSc course:

- Buckling of Structures: This mechanical failure mode is particularly critical in thin-walled structures and is of high interest to many aerospace and other lightweight structures designers
- Advanced Structural Analysis: This course educates the student in the world of thin-walled structural analysis focusing on the calculation of deformations and stresses. The course builds up a solid foundation in structural mechanics by covering the basics of strain, stress and virtual work and applying them to plate and beam problems.
- Introduction into Adaptive Aerospace Structures: This course introduces the student to the application of adaptive structures in the aerospace world. This type of structure is becoming more and more used in military and civil aerospace applications and promises to enhance the efficiency of aerospace structures.
- Structural and Non-linear structural modelling: both courses focus on Structural Modelling covering first the basic theory of the Finite Element

Method (FEM), considering static and dynamic analyses, and secondly the basics of non-linearities in the Finite Element Method (FEM), considering static and stability (buckling) analyses.

- <u>Advanced Design Optimization of Aerospace Structures:</u> A course in which the student will learn how to design and optimize a composite structure by analysing the different failure modes that can occur.

2   DESIGN OF ONLINE MSC EDUCATION

2.1 General set up

The starting point for every course that was to be developed as an online course is that in principle there is no difference between an online MSc student and a regular MSc student. This means that in principle physical presence in class is not required nor is it forbidden (e.g. online students are entitled to come and attend a lecture in the classroom should they choose to and vice versa regular MSc students can choose to not come to class and follow their class online) and all assessment can be done by electronic means (e.g. some form of electronic submission and online assessment either by electronic assessment or a webcam exam). This principle of online assessment may not be tangible for all courses but is the starting point in the design of the courses.

Each course is taught within the normal online learning environment that the TU Delft uses: Blackboard. Every course has its own dedicated Blackboard environment within which the students can navigate their way through a course. In order to successfully follow the course a student must therefore have access to a computer on which they can install software, and a communication device that has a webcam and microphone and allows them to run instant messenger software such as Blackboard IM or Skype so that they can take part in the interactive parts of the classes. It is assumed that each student has a form of word processing software available that allows for scientific reporting. All other software they may need to carry out their numerical manipulations and simulations will be selected from the large selection of available open source software so that the cost for the students remain low.

Typically within Blackboard each course starts with an online video instruction outlining the objectives of the course, the course organisation and how to navigate the course. This is combined with a written course set up document outlining all the course requirements.   Then a set of recordings follows as described in the next section. Also a section containing all assignments to the course is included. Finally, a form of interaction, be it a discussion forum, recordings of Blackboard Collaborate Q&A sessions etc. also forms part of the course.

The delivery of the lectures is done via some form of recording. This maybe a recording using the ability of Blackboard Collaborate in which lecturers teach either live or pre-recorded using a WACOM tablet or digital paper to derive the formulas and draw the structures as they 'organically' built up their theory and derivations. Another option is that lecturers are recorded in the professional TV studio at the university. Both these types of video clips are typically much shorter than normal lectures as research shown that short modules or clips keep students attention much better [8].

A final option is the recording of a live lecture in a normal classroom setting but this is really the worst of the options as the quality of this type of recording is often quite low and almost useless if the lecturer is using the black or white board. Classroom

recordings are almost only suitable if only professional presentation software is used. For this pilot use will be made of pre-recorded or live lecture clips with the classroom recordings as a back up of issues arising beyond our control.

2.2 Assessment Design

The major stumbling block in the mind of many when it comes to online education is assessment. Many hold it to be impossible to objectively assess students when they are not physically present [9]. For the courses in this particular pilot the assessment in the off-line versions of the courses typically consisted of individual assignments followed by an oral discussion or examination after the assignments were handed in. The emphasis lies on the assignments, since these show if the student has achieved the learning objectives. The oral discussion or exam will take place using either Skype or the built in meeting tool in Blackboard: Blackboard Instant Messenger. Students will have to show prior to the examination that the room is empty and sessions may be recorded for accreditation purposes. Having said that one must realise that the answers to the questions asked at these type of oral discussions or examinations rarely have closed answers and cannot be prompted by a third person or written on cheat cards. The material assessed simply is not suitable for closed questions. It goes without saying that for closed answer questions a totally different type of online assessment should be designed.
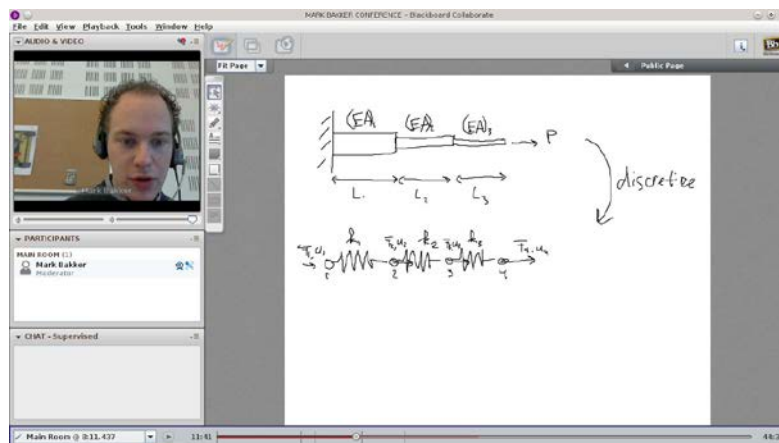

Fig. 1: Snapshot of an online tutorial using Blackboard Collaborate

In some cases students only get assignments with no oral exam but in that case each students get a different assignment to reduce the possibility of fraud. It is important for the reader to realise that the assignments usually involve the numerical analysis of a design. The solutions, which require a significant amount of work, are extremely unlikely to be found on the web or able to be 'outsourced' to others. People with the ability to complete these types of assignments are highly sought after employees and can earn a very decent living without assisting students. The risks of fraud are therefore minimal in these cases although active monitoring will continue take place, as it must always be assumed that developments will overtake us eventually requiring adjustment to the assessment.

3   EXPERIENCES AND OUTCOME

3.1 First trials

In the academic year 2012/2013 the first trials were carried out. These trials were carried out using our regular students. Two courses were run online only (no normal lectures were taught), one course was run in parallel (lecturer taught both in-class and provided each lecture as a recording also) and two classes were run in a

blended form with all lectures and tutorials recorded and posted online but with a face-to-face computer lab. Figure 1 shows a snapshot of an online tutorial. One course was run using only classroom recordings. Typically some 30 - 70 MSc students took part in each of the courses.

3.2 Early Lecturer Experiences

The predominant feeling here was that planning and preparation is everything. It is important to have a good overview of the whole course before one starts and ideally one wants to have the course and its recordings and assignments fully completed before the start of the course. That way there is much more time to deal with eventualities during the course. Second point is to stick to deadlines one sets students when it comes to assignments. The risk with anytime, anyplace, anywhere teaching is that students put off the handing in of assignments and postpone oral exams. If one is not careful as a lecturer the assessment effort controls your diary. A third point is structure. Before lecturers tended to structure everything in their lectures but in an online environment students expect the structure to be explained through the design of the electronic learning environment or a separate document or clip outlining how the course is built up and what is expected. A fourth point is that the lectures become shorter. As no interaction takes place the overall recorded lecture time reduces to some 75% of a normal lecture.

A final observation is that if the lecturer is an 'organic teacher' who prefers to derive the formulas step-by-step one must ensure to have the tools to do the job. One of the downsides of the WACOM tablets used in this experiment is their lag time in the response to the pen meaning that the voice over of the lecture is slightly out-of-sync with the writing appearing on the screen. Alternatives here are using the smart paper options available or record the lecture in a studio using the new digital smart board screens. The cost of the screens has come down considerably and the performance of the screens has improved significantly compared to a few years ago. They are also now much more affordable for education purposes.

3.3 Student feedback

Student opinion of five of the courses run online was collected using questionnaires. However the response to the questionnaires was often below n = 10 so the reporting of the results is done anecdotally. An interview with students will be done later on to receive more qualitative feedback and the reasoning behind some of the answers in the questionnaires.

When looking at the outcomes of the questionnaires a clear learning curve can be seen. The first course that was taught online ran behind in its release of assignments and release of online lectures and this really frustrated students. In follow up courses with the benefit of lessons learned it is noticeable that the frustrations disappear and students are indicating they are happier with this way of following lectures. A second real point to pick up on is the students desire for structure. Because there is not a regular class to go to which provides them with some form of structure they rely heavily on the online environment. This must contain a clear structure otherwise students get frustrated and annoyed.

Feedback is an important issue for the students; feedback from the lecturer as well as feedback from their peers. The questionnaires show that in three of the courses almost all students discussed the web lectures with their peers. Almost all students needed feedback about their assignments and discussed the assignments with their peers.

The set-up of the courses did not include formal peer-feedback even though lecturers recommend the students to collaborate. Every student has to submit his own and unique assignments. The results indicate a clear wish to collaborate and discuss with peers. The online environment should be able to support this by offering communication tools and give an indication of 'who is online with me'. Our online environment supports both with Blackboard Instant Messengers. The courses could adapt more to introducing students to each other next year since the online students who are not in Delft do not know each other yet unlike the students who were involved in the first trials.

Some of the advantages students list is the ability to go back over the lectures and the ability to take notes. Disadvantages students list is not having feeling as much part of the academic and social community of TU Delft and technical issues such as the loading of lectures. The latter issue has partly been solved by now offering downloadable mp4 files but the overall speed of running of the online learning environment is something that needs work doing on.

Some students are clearly not happy with online lectures they prefer face-to-face. It must be kept in mind that for our in-house students face-to-face is something some students still value. Possible solutions to this were the offering of online Q&A sessions. They were organised for some courses but not yet used by students. This is probably because our regular students also have the ability to come and find us face-to-face and prefer using that option. This is expected to change for completely online students.

Most students would recommend the online courses to students who cannot come to Delft, even if they were critical about the online course themselves. This can be seen a promising sign for the online master.

4   LESSONS LEARNED AND RECOMMENDATIONS

Online learning is definitely where the future is heading. In a world where people study in a format and a time that best suits them, online learning is a way of meeting those needs. The pilot discussed in this paper has shown that going online despite having its downsides in the enormous amount of investment of time and human resource in the initial set up and the changes an organization must go through, is definitely the way forward. In its worst case it offers opportunities for regular students to revisit all of the learning materials including its lectures. It also allows students who for some reason cannot be physically present at the university to continue studying thus increasing study efficiency. At best the knowledge dissemination increases as the subjects are opened up to people who previously did not have access to these courses. Both students and staff who took part in the trial so far are enthusiastic about its possibilities both now and in the future.

However, going online is not without its challenges. The authors would urge their colleagues who consider going online to not go it alone. Work together in a team with all relevant stakeholders and learn from each other. Also as with many things preparation is everything. As one is dependent on technology one must allow time to fix errors and deal with the unexpected. Draw up a clear framework in which expectations the lecturer has are outlined and also what students may expect from the lecturer. This avoids discussions and feelings of unease afterwards. This all requires advanced planning. Finally, involve (previous) students with development of the course. Their knowledge of online technology and its applications and their desire for good education will assist anyone in making their course better.

5 ACKNOWLEDGMENTS

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