OER & Engineering: Supporting Engineering projects through OpenCourseWare
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Abstract
In the following the results of targeted OpenCourseWare publications to support engineering projects will be presented. Preliminary findings show improvements in project outcomes, staff & student engagement and quality of education. The projects topics concern a design competition by TAHMO, aimed at developing a low-cost weather station for sub-Sahara Africa and DUT-Racing, a student racing team at Delft University of Technology. This paper bases itself in the discipline of Science & Technology Studies, and presents qualitative findings on two case studies from Delft University of Technology in which specific courses have been published as OpenCourseWare in order to support ongoing engineering projects.

Keywords
OER, Open Education, OpenCourseWare, Engineering, project, design, education, quality, access, design competition, TAHMO, DUT Racing.

Introduction
Delft University of Technology has been publishing OpenCourseWare since 2007, and currently has over 120 courses published. Our number of OpenCourseWare is still steadily growing and Delft University is committed to sharing it’s knowledge openly. In 2013 we started to publish courses catered specifically to ongoing engineering projects at our university. In 2013 Delft University of Technology has actively supported two projects by publishing targeted OpenCourseWare content. One project involves the Delft University of Technology (DUT) Racing team, one of the multi-disciplinary student racing teams of Delft University. The other project evolved around a design competition from the Water Resources Management group (Civil Engineering and Geosciences faculty) that aims on setting up a Trans-African Hydro-Meteorological Observatory (TAHMO). In the following we will show how this has brought more engagement from students and staff, has improved our education and provided relevant background information to those interested in the supported projects while simultaneously expanding our OpenCourseWare.
While staying true to the original OpenCourseWare concept - to share our knowledge openly -, this added the benefit of creating more commitment from our staff and students towards OpenCourseWare and allowed us to engage a more specific audience. Moreover it provides the opportunity to show how research activities and the engineering and design theories in our education are translated into tangible and concrete applications and products in engineering projects. OpenCourseWare also enhanced the reciprocity between education and project-based engineering by functioning as concrete case studies that were subsequently used to improve the courses to which they related.
In the following the two projects involved will be introduced together with an outline of how OpenCourseWare played a role in the project. Hereafter the additional benefits brought by the ‘project-based’ approach of broadening our OpenCourseWare collection will be presented and shortly discussed. These results will be summarised and to form a more general conclusion on the impact and benefits of publishing specific courses as OpenCourseWare in supporting engineering projects.
Projects
In 2013 OpenCourseWare content has actively supported two projects. One project involves the Delft University of Technology (DUT) Racing team, a multi-disciplinary student racing team. The other project evolved around a design competition from the Water Resources Management group (Civil Engineering and Geosciences faculty) that challenged participants to develop low-cost weather sensors. This effort is supportive of their goal of setting up a Trans-African Hydro-Meteorological Observatory (TAHMO).

Case Studies: Results and findings

DUT Racing

Each year DUT Racing joins the Formula Student competition in which they design and build their own race car as an extra curricular activity. The team won the Formula student competition in 2013 while also setting the world record for fastest acceleration of an electric car (0-100 in 2.13s). Next to their aim of winning the competition, the main focus of the team is educating their team members and the broader public.

Together with the team we worked on indentifying the courses that show how the theories and design principles our engineering students take from their education apply to the design and build of the car (http://dutracing.tudelft.nl/explore-the-car/ and http://ocw.tudelft.nl/more/dut-racing/), and published those courses as OpenCourseWare. In doing so, these courses also allowed us to show how practical activities our students perform lead to a concrete design, in this case a world record race car. In the process of identifying the university courses relevant to the design of the car, the students were forced to reflect on the knowledge and theories from their general courses to jointly identify those courses that they applied in the design of the car. This list of courses also serves as a tool for prospective team members to tailor their choice of courses towards racecar engineering.

The courses we published as OpenCourseWare for DUT Racing, 15 in total, ranged from basic courses in Materials Engineering and Statics & Stability to more specific courses such as Race Car Aerodynamics. In doing so we also found the teaching staff very supportive in cooperating with us to publish their courses openly for this specific project, because of the connection to the DUT Racing project. The ‘Elementary Ergonomics’ course from our Industrial Design faculty has taken the car design as a case study and recorded a video-lecture on the specific topic to support the initiative. Currently the course ‘Race Car Aerodynamics’ is also incorporating the DUT Racing design as a case study.

The project based approach to publishing OpenCourseWare has thus brought not only increased engagement and enthusiasm from our teaching staff, it also ensures that what students do in their engineering project flows back into the regular courses taught at Delft University. In doing so the course quality is improved, students are shown where and how the basic theories can be applied and lecturers are provided case studies for their lectures, while also expanding our number of OpenCourseWare.

The abovementioned results have focussed largely on the internal processes within the university and its effects on students and staff. However there are also benefits that expand beyond the institution. For example the project provides a great example to young (prospective) engineers of the options a technical education provides them. Furthermore the courses have also spiked interest from other Formula student teams, the team sponsors and the general public that is interested in the DUT Racing project. From the OpenCourseWare perspective the link to the
DUT Racing project provides an additional path to access OpenCourseWare; not just through the regular Delft University OpenCourseWare website which is the regular means of access, but also through a project website that spikes the interest more easily because of its strong link to the race car design.

TAHMO

The second project involves an initiative called the Trans-African Hydro-Meteorological Observatory (or TAHMO). It is based at our Civil Engineering faculty and the aim is to develop and place 20,000 low-cost weather stations across sub-Sahara Africa to gain valuable climate data. This will benefit both local farmers in ensuring their food security and additionally provide researchers data (which is currently unavailable) to implement in their hydrological models. In order to ensure that appropriate technologies are developed and to garner support and build an African network, a Design competition was organised in which African universities were challenged to design a sensor for the low-cost weather stations that are being developed. In order to support the participants of the design competition we published seven courses that were either related to hydrology and watermanagement or electronic instrumentation and it’s applications. In doing so we managed to provide a clearly defined audience support in reaching their goals in the sensor design competition, while additionally educating them on the hydrological necessity of gathering weather data. Additionally the courses were made available offline, so that they could be shipped on a flash-drive together with the ‘maker packages’ that were provided to the team, in order to provide them parts and course materials to ensure they could build the sensor they had designed. Shipping the courses on a flash-drive ensured that broadband connectivity would not hamper the teams ability to access the course materials. Again when approaching teaching staff with the question whether they would like to contribute to the project by publishing a course as OpenCourseWare we found that, because of the clear audience we defined and the tangible project it connected to, it was easier to engage staff in OpenCourseWare. Despite limited time to prepare the courses we managed to publish seven courses within a three-month time frame. One of the lecturers even translated the course he taught in Dutch to English to benefit the participants of the TAHMO design competition. Following up on the sensor design competition the best designs were invited for a week-long workshop in Nairobi, Kenya to connect all of the sensors and make their measurements available online. This provided the opportunity to question the participants about how useful the OpenCourseware had been and the majority of the participant had gotten valuable information from the courses, and even requested if we could publish additional courses on the topic. The courses published for TAHMO did not have the same effect on the improvement of our regular education as for DUT Racing; so far it has not provided concrete case studies for regular education. It does however provide us a basis for a re-run of the design competition in 2014, while also providing background information to our on-campus students for a course with a similar aim to the design competition. Ultimately we managed to reach and support a group of engineers that were in need of specific knowledge that they otherwise would have a hard time gaining access to. Our efforts for TAHMO now can be used as another good example of ways in which OpenCourseWare can be put to use to support projects and fulfil a need for education.

Conclusions
Our efforts for TAHMO and DUT Racing have provided us a way to create more impact, engagement and spin-off from OpenCourseWare than our standard publication process. For TAHMO we aim to further tailor and expand our OpenCourseWare on the topic to support the next round of the design competition in 2014. The project with DUT-Racing has provided us a template for the other student racing teams at Delft University. In the future we hope to work together with more world-record holders from our university to further engage students, staff, the public and prospective engineers.

While these two projects are fine examples of what OCW can do in order to support projects, it also shows a way of gaining the additional benefits of engaging students, teaching staff and ‘outsiders’ with course content because of the strong link to the practical and tangible projects described above. Furthermore it has a strong focus on engaging a broader audience, and prospective engineers, with the STEM disciplines at Delft University of Technology, and shows where and how these can be applied to result in concrete designs and projects. In particular the TAHMO project strongly focussed on making OpenCourseWare available to a less privileged group of engineers, and has taught us valuable lessons of the limitations of our traditional delivery of OpenCourseWare.

The engagement and the positive response we got from these initiatives is something we couldn’t have got to without publishing project related packages of OpenCourseWare. The above described case studies provide an overview of what types of additional benefits can be generated by taking a more project focussed approach in deciding which courses to publish as OpenCourseWare. It also shows how the effectiveness of Open Education in general can be improved by making sure there is a clear target audience, while incorporating the traditional value of OpenCourseWare of making our course materials available as openly as possible.

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