Delft University of Technology

TU Delft Online Learning Research Working Paper #1

DelftX MOOC Course Report ET3034Tux Solar Energy (2013)

TU Delft

This report aims to provide an insight into the background, the implementation and the results of the course. The information in the report and clean data accompanying it may be of relevance for MOOC developers, teachers and others in their aspiration to improve open and online education. A cross-course comparison of the first five DelftX MOOCs can be found in the 'Working Paper DelftX MOOCs, the first year (2013-2014)'.

Acknowledgements
We would like to thank the MOOC teachers, the developers, the New Media group, all the other stakeholders we interviewed and the DelftX team for their cooperation. In particular, we want to thank Christopher Davies (http://enipedia.tudelft.nl) for his help cleaning the raw data and providing us with useful code for analysis in R.

This report was developed by
Pieter de Vries & Thieme Hennis (TU Delft)
Sasha Skrypnyk (University of South Australia)
Pascal Gemke (TU - TBM)

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Course report 2013 - 2014

TU Delft Online Learning Research Working Paper #1

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Summary

Name course	ET3034Tux Solar Energy (SolarX)
Date	16th of September to the 8th of December 2013
Faculty	Faculty of Electrical Engineering, Mathematics and Computer Science
Teachers	Dr. Arno Smets
# of students	57091 enrolled, 2730 received certificates of completion
Level and prerequisite	BSc level with basic knowledge in physics and familiar with mathematical skills as integration and differentiation
Course resources	Video lectures with exercises; demonstration animations, special student project, organizational support in form of formular sheets, calendar, additional exercises
Suggested workload	8 hours/week
Course on edX	https://courses.edx.org/courses/DelftX/ET3034TUx/2013_Fall/info

The course was designed as a foundation course in Solar Energy, requiring basic knowledge of physics and some mathematical skills. It consisted of 7 modules and an introductory week. The course was at a bachelor-level, designed for a broad range of students. Basic knowledge in physics and such mathematical skills as integration and differentiation were required. In the course video lectures were used, convergent exercises, tests, and animations for illustrating relevant engineering and physical phenomena. It was frequent feedback on the forum from.the news and announcements, included two feedback videos from the teacher and high feedback from the teacher, staff, and selected teacher assistants. The course had a flexible assessment strategy, i.e. the student had a selective choice of which exams to take and still allow a student to successfully complete the course.

The most common reason to subscribe to the course was ‘To increase my knowledge and skills’. The median student age was 28 with a majority of 44 % in the age of 26 to 40 and 74% of the students were male and 15% female. It is clear that the participants constitute a very diverse group of people of which a large part is employed (50% fulltime, 14% part-time) and many of whom have a career in a relevant field.

The biggest challenge for the teacher / developers was time pressure, obviously related to the newness and complexity of the development process of a MOOC. Part of the complexity is the intention to deal with the variety of students in age, location, schooling, living conditions, etc. which is very different and requires a different mindset. Overall, the satisfaction was very high and this was also shown by the high number of students (80%) who intended to continue studying in this field.

1. Introduction

The ET3034TU Solar Energy course from the faculty of Electrical Engineering, Mathematics and Computer Science, in particular the Photovoltaics Material and Devices group at the Delft University of Technology ran for 7 weeks in the period of the 16th of September to the 6th of December 2013. In total 57091 participants registered and ultimately 2912 completed the course and received a certificate, which is 5% of the total. This was one of the two first MOOCs produced by the TU Delft.

The course was designed as a foundation course in Solar Energy, requiring basic knowledge of physics and some mathematical skills. It consisted of 7 modules and an introductory week. The course was at a bachelor-level, designed for a range of students. The main learning goals were the discovery of solar energy power and the design of a complete photovoltaic system. This was done by introducing the student to the technology for the conversion of solar energy into electricity, heat and solar fuels with a main focus on electricity generation.

This report contains additional information about the background, the implementation of the course and the results with the purpose to add to the knowledge base of MOOC environments. The information in this report has been collected from different sources like edX subscription data, edX student data, including the use of the forum. Using a pre- and a post-course survey made it possible to collect qualitative information on issues like expectations, motivation, prior knowledge level, and relevance and correlate the outcome with other data. In addition the teachers and the development team were interviewed to acquire more insight in their experiences and perceptions.

The main purpose of the analysis was to provide useful information (and clean data) to the team of developers and teachers to improve the design and facilitation of subsequent online courses. This was organized by the O2E research team (Open and Online Education) from the TU Delft in close collaboration with researchers from the University of Southern Australia.

2. Course design and pedagogy

2.1 Design, Learning Resources and Workload

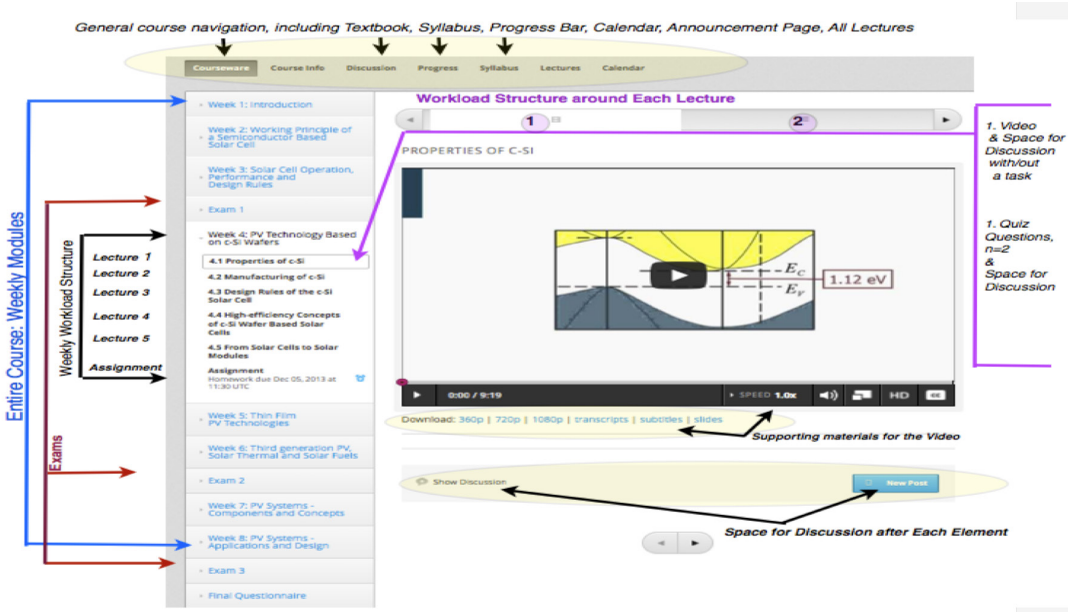


Image 1. Screenshot of the Structure of SolarX

The course was designed as a foundation course in Solar Energy, requiring basic knowledge of physics and some mathematical skills, and taught by Dr. Arno Smets. It consisted of 7 modules and an introductory week. The course was at a bachelor-level. Basic knowledge in physics and such mathematical skills as integration and differentiation were required. The number of sub-topics weekly ranged from 2-5. The grading was divided into 5 assignments, comprising 40% of the final grade and 3 exams, which equaled 60% of the grade. The passing grade for this course was 53%.

Overall video content was approximately 9.9 hours, and information heavy. The staff acknowledged the uneven work distribution of workload. The estimated workload was, 'around 8 hours per week'. Approximately 40% of the students worked between 5 and 10 hours per week. 29% worked less than 5 hours and 31% worked more than 10 hours.

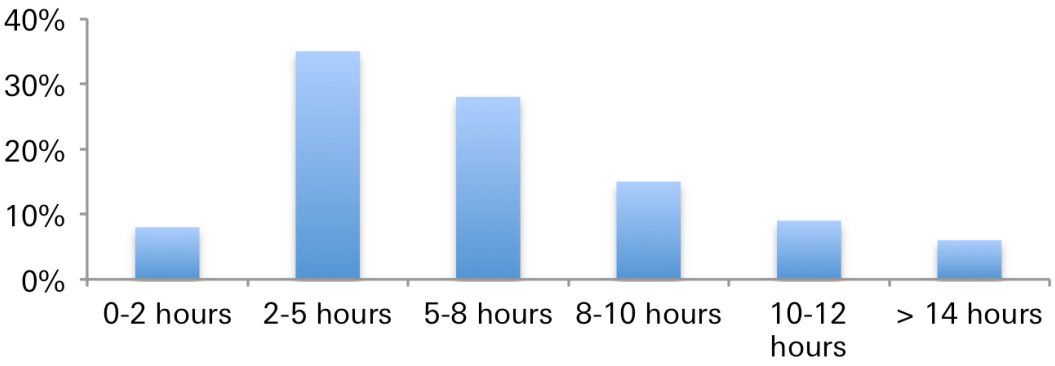
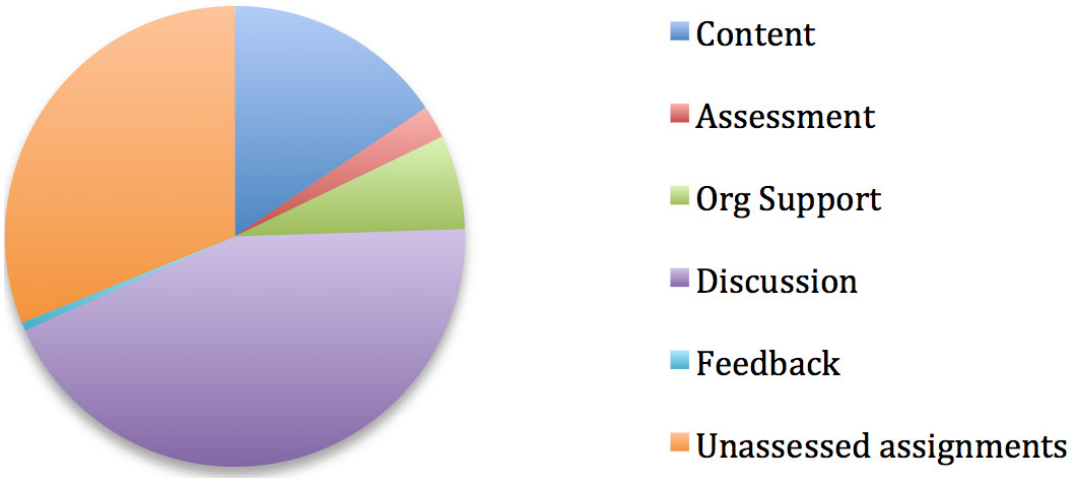


Figure 1. Estimated workload in hours per week

86% of the students who completed the course found the amount of work they needed to do for it to be “just right”. 14% thought the workload was “too much”. 87% of certified completers found that the level of the course was “just right”, 13% thought it was “too high”. Almost all students found the pace of the course “just right” (99%). 76% of the students considered the duration of the course “just right”, but 19% found it too short.

The course contained video lectures, convergent exercises, tests, and animations illustrating relevant engineering and physical phenomena. It was regularly updated with the news and announcements, included two feedback videos from the teacher, high feedback from the teacher, staff, and selected teacher assistants. Sub-forums were embedded into the course structure. Overall, the balance of the learning resources for the course is visualized in Graph 1.



Graph 1. Balance of the Learning Resources in SolarX

2.2 Student Feedback on the Course

The average rate given by the respondents for the overall quality for SolarX was 4,56 out of 5 (range is from 1: Very poor to 5: Excellent). The students rated the teaching with 4.58 out of 5. The chart below shows the rates of the other elements of the course:

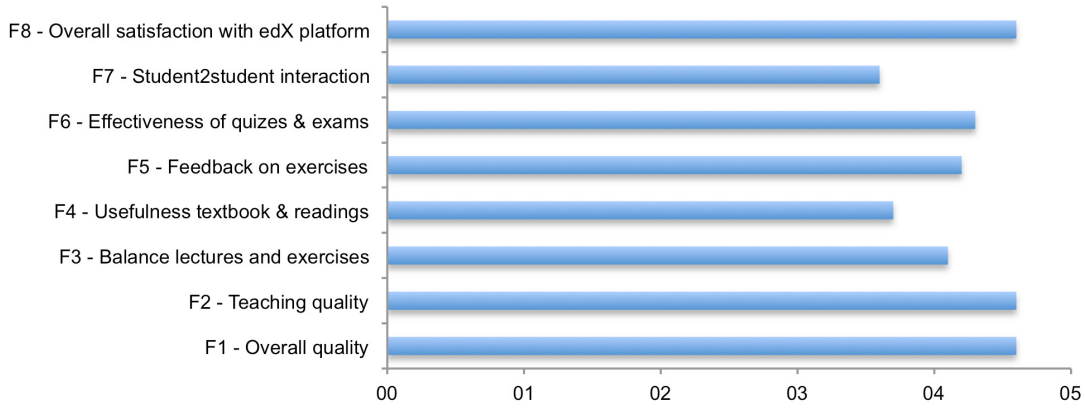


Figure 2. Satisfaction and Feedback on Course

Overall, the satisfaction is very high, but this can be expected, the post-course survey has a strong bias towards completing students. In the following illustration below, we see that students respond quite positively on all measures of quality. However, it seems that students would have liked to have more worked examples. About half of the students prefer 'open deadlines' rather than 'strict deadlines' for assignments and exams.

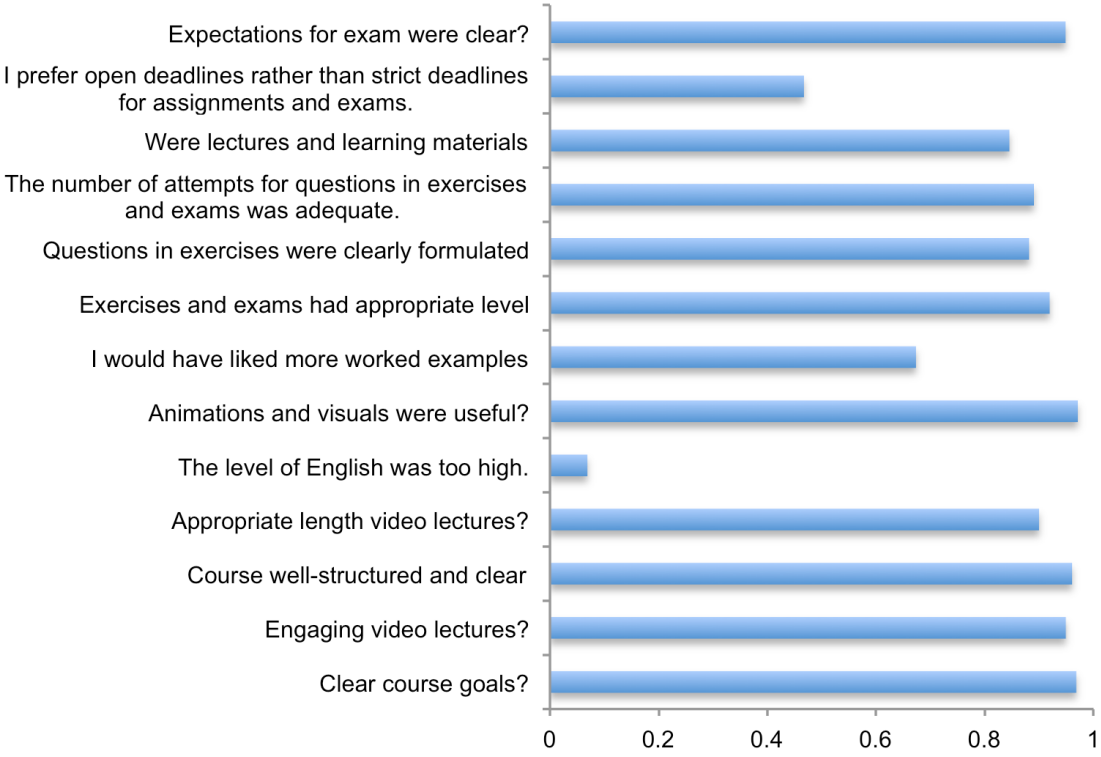


Figure 3. More feedback students (course, teaching, materials)

We also asked about technical issues encountered by students. While the majority of students did not encounter any technical issue (68%), among those students who had encountered technical issues, the most important were 'Slow internet connection' (17%), 'Limited access to a computer' (5%), and 'Difficulty navigating the edX platform'(5%).

3. Student demographics

3.1 Registered Students

74% of the enrolled students were male, 15% - female. Over 50% of the enrolled were 19-30 years old, and over 50% of the registered had either Bachelor's or Master's degrees. 36% for SolarX indicated that they had a professional occupation related to the course. 40% of the employed participants indicated that they were allowed to work on the course during working hours. Most students (66%) indicated that they had no prior experience with Solar Energy. It is also this group that has a statistically significant lower grade (.39) than students with experience in the topic (.47). The grades become more similar when you increase the threshold for including data. For example, when take all students with a grade higher than .1, the mean difference is still statistically significant, but is only .03. When the threshold increases even more, the difference becomes very small and no statistically different. This shows that students with little to no experience are less likely to start or to persevere at the start of the course. Why this is so, is not clear, but it is worth looking into.

Category	N (grade>0)	Mean grade	N grade>.1	Mean grade	N grade>.2	Mean grade
No prior experience	3000	.39	1725	0.66	1467	0.75
With experience	1481	.47	962	0.69	863	0.76

Table 1. Prior experience and grades

The majority of students registered identified themselves as from either the US or India. The number of Asian students was relatively low. Table 2 shows the break down for top 20 countries of origin. Three questions were asked to identify students' cultural background in a more elaborate manner: "Where were you born?" (Column Born), "Where do you live?" (Column Lives in), and "Which country did you get your latest degree from?" (Column Was educated). For example, although a total of 21% of students identify themselves as born in the US; 23% are American-educated, and 25% are residing in the US. Such slight variation points towards a more culturally diverse American students group, which also includes US-educated immigrants, and non-US educated immigrants. Several other countries have the same dynamics. Although the variation is small, from our further research we learnt that students with Mixed cultural backgrounds, e.g. born in one country, studied in another, and living in the third, make up about a quarter of completing students, and have complex learning and interaction preferences.

	Born	Lives in	Was educated
United States	21%	25%	23%
India	23%	21%	21%
Spain	7%	7%	7%
Netherlands	6%	6%	6%
Brazil	5%	5%	5%
Colombia	5%	4%	4%
Mexico	5%	4%	4%
United Kingdom	3%	4%	5%
Pakistan	4%	3%	4%
Canada	3%	4%	3%
Nigeria	3%	2%	2%
Greece	2%	2%	2%
Philippines	2%	1%	2%
Australia	1%	2%	2%
Egypt	2%	2%	2%
Germany	1%	2%	2%
France	1%	1%	2%
Portugal	1%	1%	1%
Italy	1%	1%	2%
Chile	2%	2%	1%

Table 2. Top-20 countries of origin, currently living, and received education

Disregarding the minor differences, it can be generalized that the majority of registrants came from English-speaking and South East Asian cultures, followed by Latin American and Latin European cultures.

In the pre-course questionnaire, the students indicated a variety of reasons for enrolling in the course (Figure 6). The most common reasons were 'To increase my knowledge and skills', 'To challenge myself', 'Because I find the topic interesting and fun' and 'To earn a certificate'. When we look at the goals of the students regarding the completion of the course, most of them were initially 'committed to do all the work and earn a certificate', however not everybody accomplished this goal. The reasons for participating did not differ across the courses, the reasons are shown in the chart below.

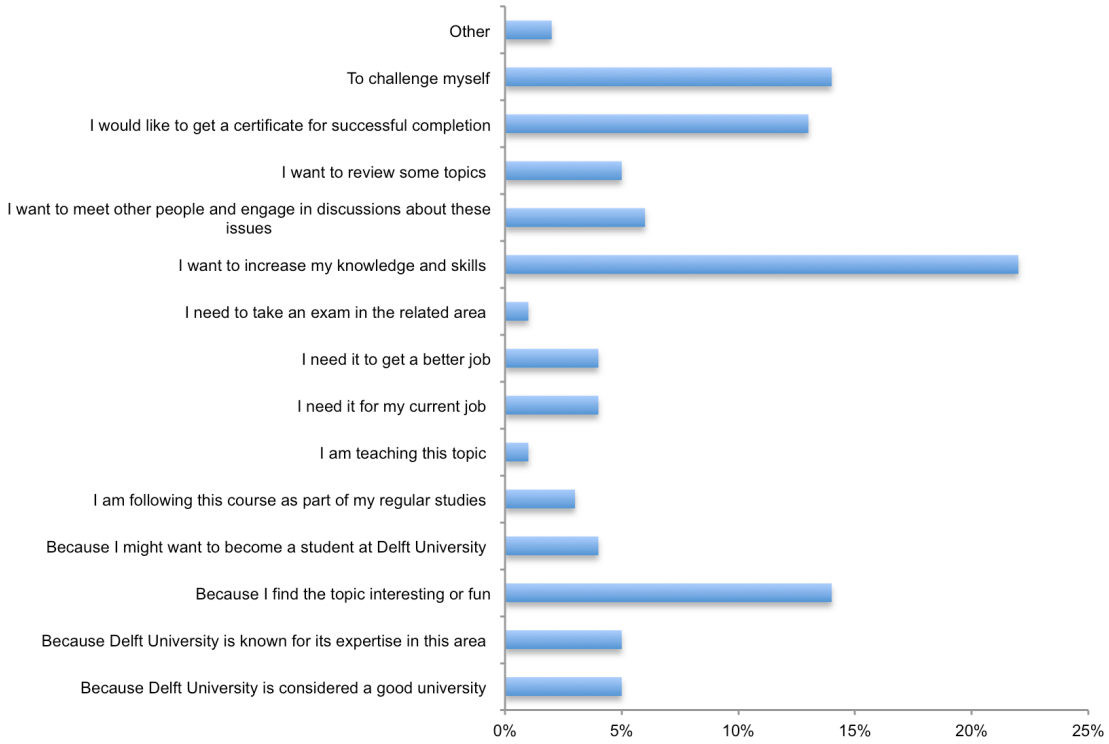


Figure 4. Reasons for taking this course

Most students, found out about the course through the edX website. It seems that many students already have experience with edX, or at least knew the website and browsed to find a course.

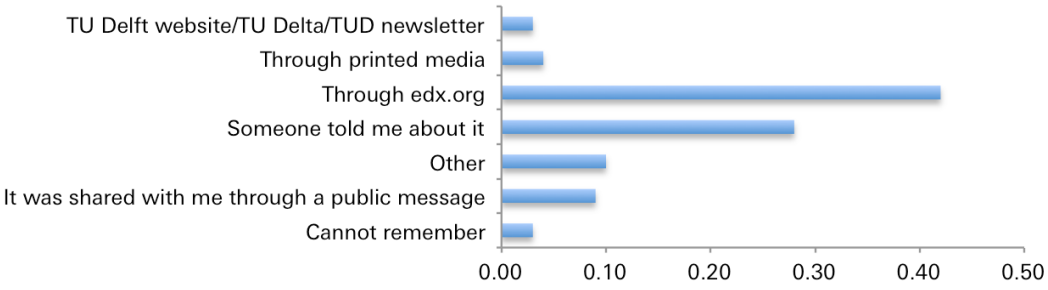


Figure 5. How did you find out about the course?

3.2 Students Receiving Certificate of Completion

75% of the completing students who received a passing grade of 53% in the course (N=2891) were male, 10% - female, information about the others was not available. 50% of those who completed the course were 19-30 years old, 25% were within the 31-50 years old range. The majority of students who received certificate of completion came from South-East Asian countries, such as India. The second largest group of completers is from Latin American countries, followed by Latin Europeans and English-speaking participants. Over 50% of completing students had master's or bachelor's level education. For more details on the demographics, please see Appendix 1.
Additionally, 60% of the completing students who received a passing grade indicated having no prior background in the subject in their pre-course surveys (Figure 6). Such demographics illustrates that the teacher was successful in his intention to develop a course for a broad audience. However, as we saw before, there is a statistically significant difference in grades between those who do have prior experience and those who do not.

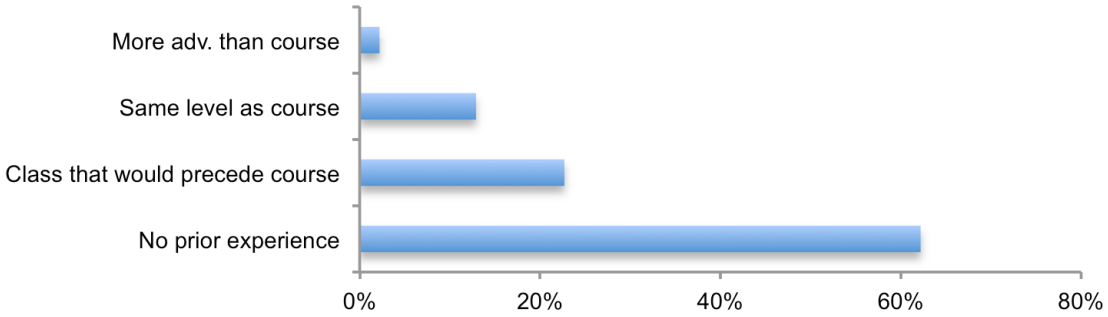


Figure 6. Prior Experience in Topic (Completing Students)

In pre-course questionnaire, we asked the learners what they believed was the most important quality for completing the MOOC: "knowledge" or "effort" put into learning. This stems from research into student psychology and the attitude they have towards intelligence. It has been shown that students who perceive effort as more important than intelligence perform better. However, we do not see any difference in the grades between these two groups (figure 7). Most students consider effort a more important reason for course completion than being knowledgeable about the topic. Further examination of prior backgrounds of the completing groups of learners, who believe in knowledge as key to success, may shed some light into their persistence patterns.

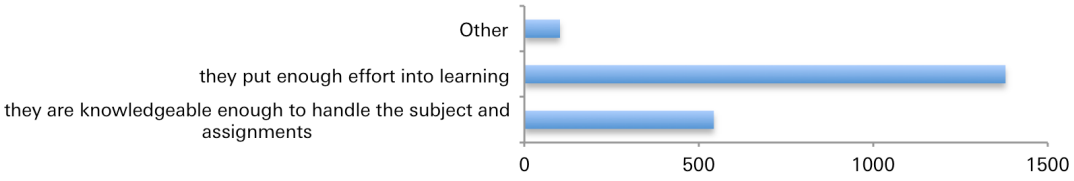


Figure 7. Beliefs in persistence

4. Retention and formal performance

44% of students who engaged in the first homework assignment in SolarX received the passing grade of 53%. The average grade in the course is 89% (for details, see Appendix 2). The course had a flexible assessment strategy, i.e. it would have been sufficient for a student to only do the three exams to receive a passing grade, as well as high grades for homework and low performance on exam, or selective choice of which exam to take, would also allow a student to successfully complete the course. From figure 8, it could be seen that most drop-out occurred between the first and the second homework, and the second largest drop-out curve is seen after the third homework.

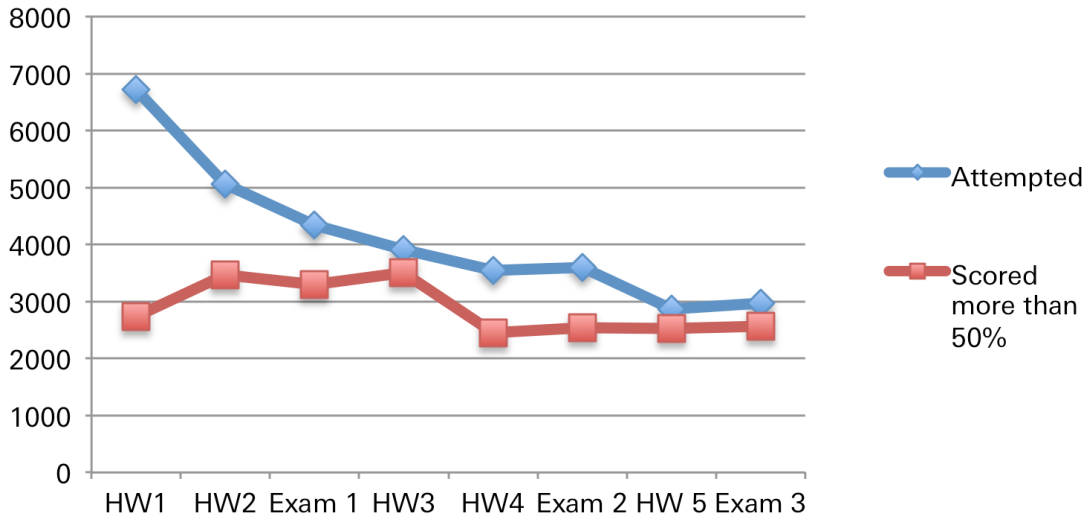


Figure 8. Formal retention in the course.

We asked the students who did not complete the course how they would describe their participation and why they didn't complete the course. 138 participants have submitted their answers. The chart below provides an overview the level of the level of participation of students who identify themselves as being inactive. The most common 'inactive process' was to follow the course whenever the student had time. The chart that follows shows the reasons for inactivity.

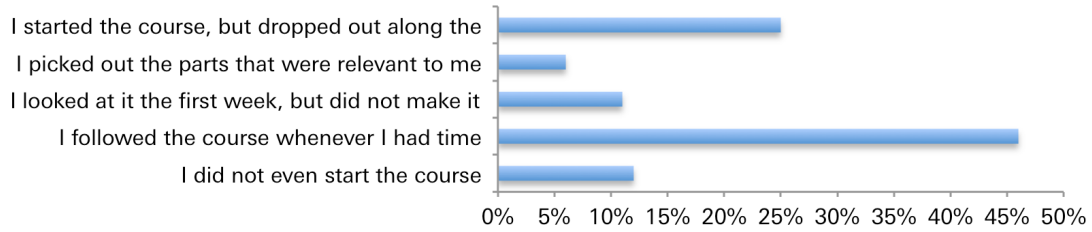


Figure 9. How would you describe your participation?

By far, the most important reason for inactivity was not having sufficient time to follow the course and do the assignments. Another group indicates personal and work-related issues as reasons for inactivity. For 4% of the inactive respondents, a lack of accessibility and/or technical issues were the most important problem.

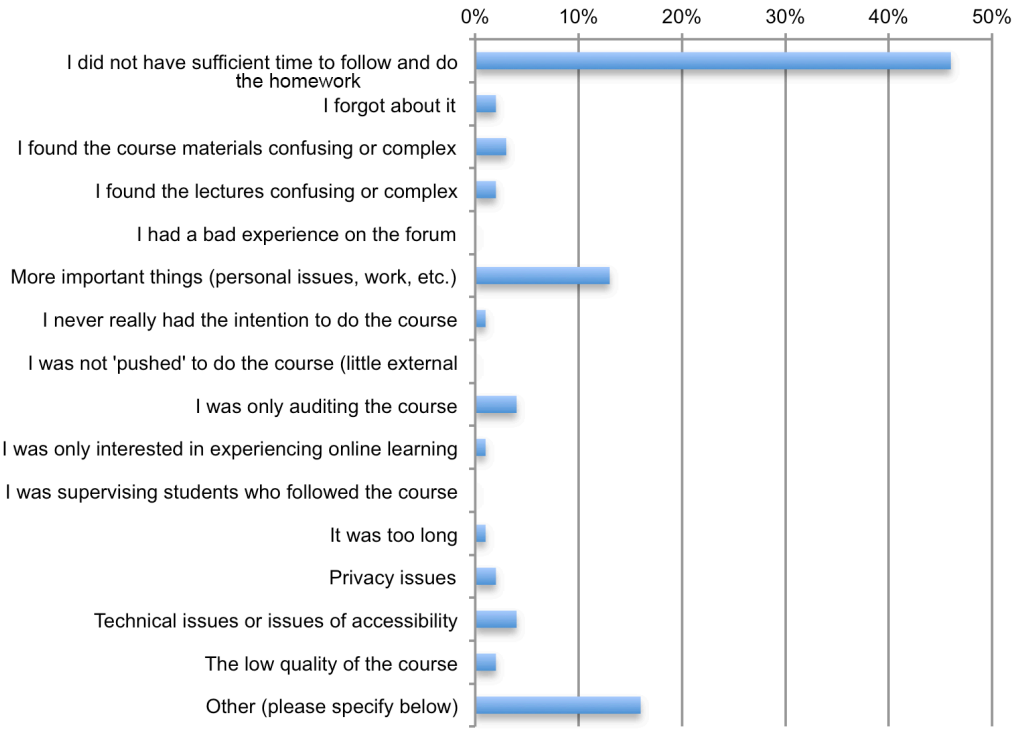


Figure 10. Reasons for becoming less- or inactive

5. Course forum and student interaction

5.1 Student Reported Interactions

The charts below show the answers reported by students in a post-course questionnaire, in relation to their peer-to-peer and peer-to-teacher interactions within the course. An analysis of variance points out that students who interacted with "Nobody" have a statistically lower grade (.82, n=496) than those who did interact with someone else (.87, n=860). This also holds if you take just the students who passed the course (.86 vs .89). Even though the differences are quite small, they may have meaning, as we are also seeing a correlation between forum posts and grade, even above a certain threshold. Further exploration of the actual interaction students have during a course can help us understand the value of interaction and collaboration during online courses more deeply.

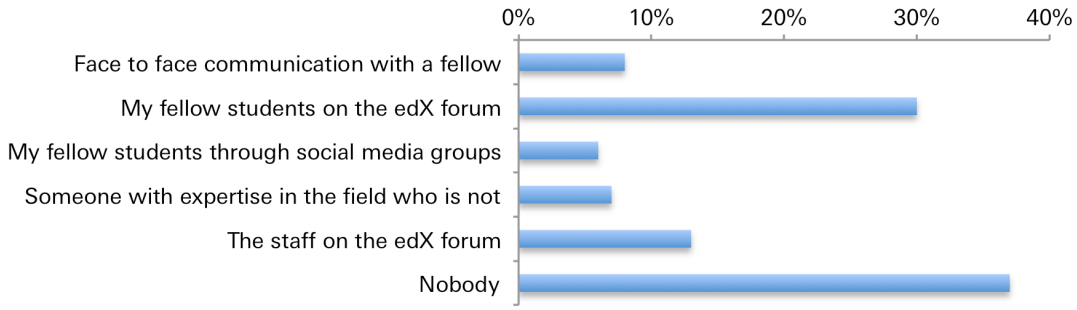


Figure 11. With whom did you interact?

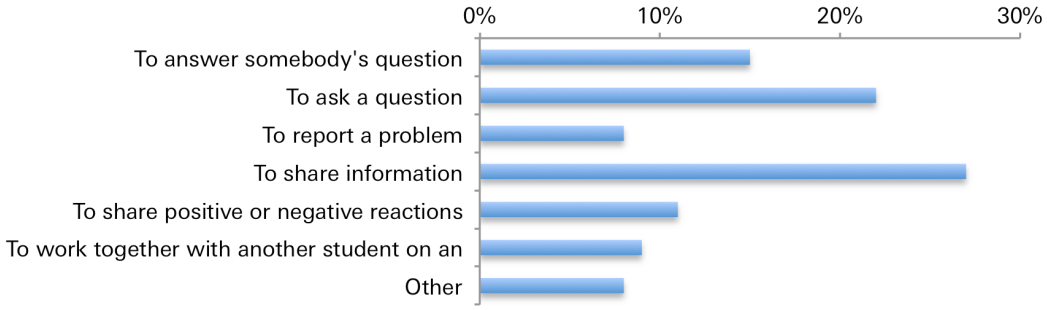


Figure 12. What was the reason to interact with other students?

5.2 Course Completion and Use of the edX Forum

In order to show the activity on the forum, all the completing users were classified into several groups: passive, (i.e. those who made 0-3 comments, e.g. "My name is …", one one-threaded post about an opinion, and "Thank you for this wonderful class"); inactive (4-6 posts); moderately active (7-14 posts), active (15-29 posts), very active (30-49 posts) and super-posters (50-700 posts). Table 3 and table 4 present more detailed information about the volume of social activity shown by the competing students.

	Solar
Total # of posts produced by all completers	14219
Max # of posts per person	681
% of completers who made "0" posts	47%

Table 3. Number of posts and completion

	Solar, %
Super posters (50 - 700 posts per person)	1,03
Very active (30-49 posts per person)	0,96
Active (15-29 posts per person)	3,06
Moderately active (7-14 posts per person)	7,79
Inactive (4-6 posts per person)	9,76
Passive (0-3 posts per person)	77,4

Table 4. Frequency of posts per course

In Solar the highest activity among people with grades 90-100%. The forum was embedded into all of the course modules, and stimulated in an on-going manner by course staff and appointed teaching assistants recruited form the student body. More specifically, four students appointed to be community. As are among super posters (top 1% of students who produced 46% of comments), and the number of individual posts they made is as high as 681 per person.

Table 5 shows the distribution of activity among the group of completing students, as well as what is the ratio of posts they produced. In Solar, we see two disparate groups of "very active" and "active", and a very large group (and a long tail) of inactive.

Course	**Solar Energy**	
	% of completers	*% comments they made*
Inactive (0-3 posts)	77,38	10,33
Active (3-50 posts)	21,56	44,52
Very active (50-700 posts)	1,03	45,15

Table 5. Course Completion and Participation on the edX forum

5.3 "Vocal" MOOC Completers

We have analyzed basic demographic factors of 46 completing participants who produced half of all the posts made by the group of completing students. This was done to gain a general idea as to what kind of learners are vocal on the forum of this course. In that sense, forum was mainly male-dominant, and half of the group was young people in their 20ies. Culturally, participants were from South East Asia and Middle East, followed by English speaking and Latin American learners. This cultural dominance is very peculiar and different from the cultural dynamics on edX forum we observed in other DelftX forums.

Vocal learners had background educations levels equal to bachelors, master's or high school education.
In the completing group, learners from developed countries were older (50-60ies) and from developing countries, such as India, younger: early 20s. Both demographics generally have high-school education as prior background.

6. Looking back

A post-course survey for students and a post-interview with the teachers and developers of the course allowed us to collect some qualitative information on the experiences of the participants. The pre-survey had 1560 respondents; the post-survey had 1403 respondents while 2912 students received a certificate, so this could mean a 48% response assuming that only the completers filled out the survey.

From a research perspective it was interesting to see what these students were doing and what their perception was looking back after successfully finishing the course. Therefor the post-survey zoomed in on issues like confidence in handling the course, how determined they were to finish the course, the use of the online forum, social interaction, the relevance of the course, the challenges, their expectations and experiences, course quality and the question if the course inspired them to continue learning?

The course was highly appreciated and more than 95% would recommend the course to others or take a course given by the same team. Also the course inspired more than 80% to continue studying in this field or even consider an online graduate course (50%). About 35% of the students had a professional occupation related to the course and 40% of the employed people specified that they were allowed to work on the course during working hours. When asking about their background in the topic of the course, we see that 73% of SolarX students had no background in the course topic.

When asked why they took the course, the most common reasons were 'To increase my knowledge and skills', 'To challenge myself', 'Because I find the topic interesting and fun' and 'To earn a certificate'. Most students (87%) found that the level of the course and the pacing was just right.

Students who did not complete the course were asked why. The response for these questions was rather low (138) so the sample is not representative for the entire population of 'inactive' students, which amounts up to thousands of students (depending on where you draw the line for 'inactivity'). The most common 'inactive process'was the lack of time.

From the analysis of the course a few things emerge: students would like to have more worked examples (step by step); for some English was a problem (understanding the topic); questions in the exams were sometimes unclear and more attempts are wanted; materials and explanations were not sufficient for completing the exercises.

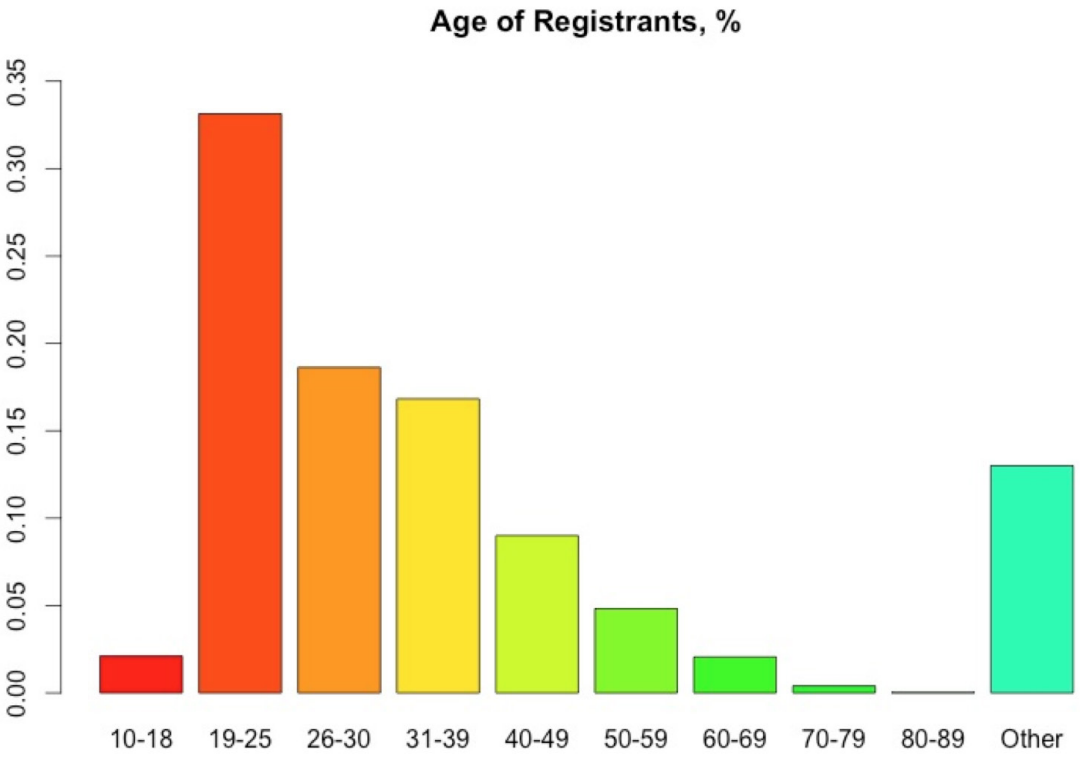
Teachers and developers

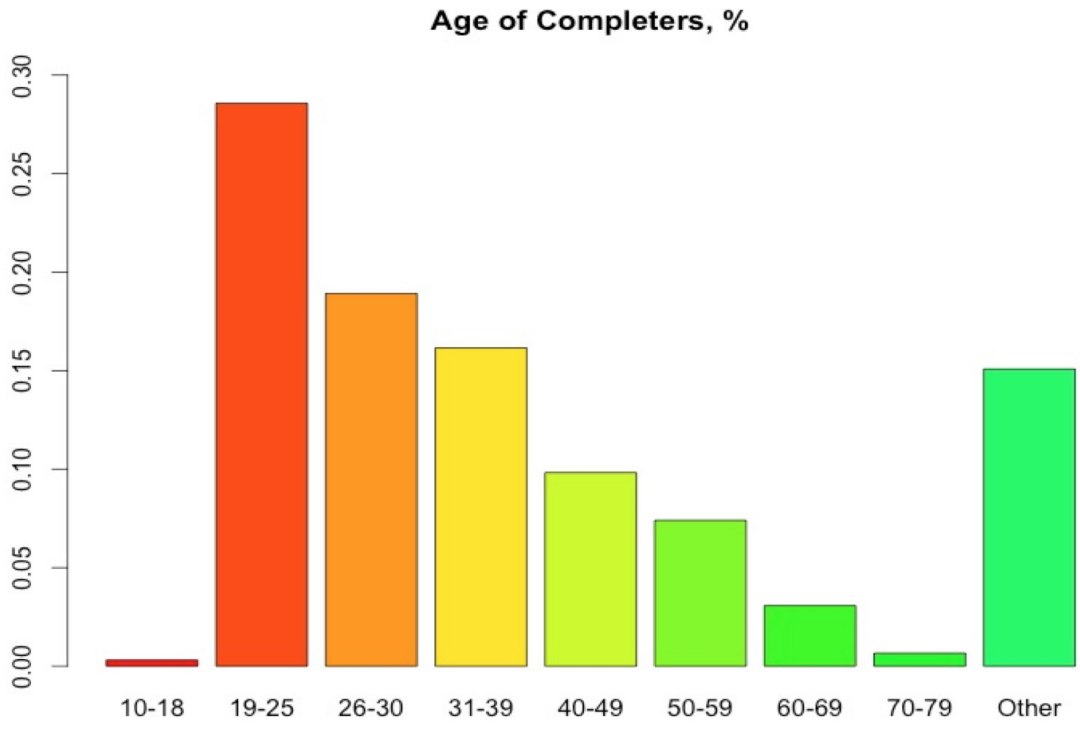
The primary goal of the developers of SolarX was to show their expertise in the field of PV technology by delivering a high quality course. Other stakes were the Marketing for PV masters, the usage of MOOC material in on campus education and to improve on campus education. The biggest challenge was time pressure which is obviously related to the newness and complexity of the process and the rather short period of time for development.

It is clear that the variety of students in age, location, schooling, living conditions, etc. is very different and highly demanding and needs a different mindset from the developers and teachers. Adapting to the different context, the different environment, the different organization, requires a 'teacher as architect for learning'attitude, much more than in regular education. Exciting are the opportunities to 'read'the learner more than before, although data analytics is still to be developed to help the teacher to keep track of what is going on and react accordingly.

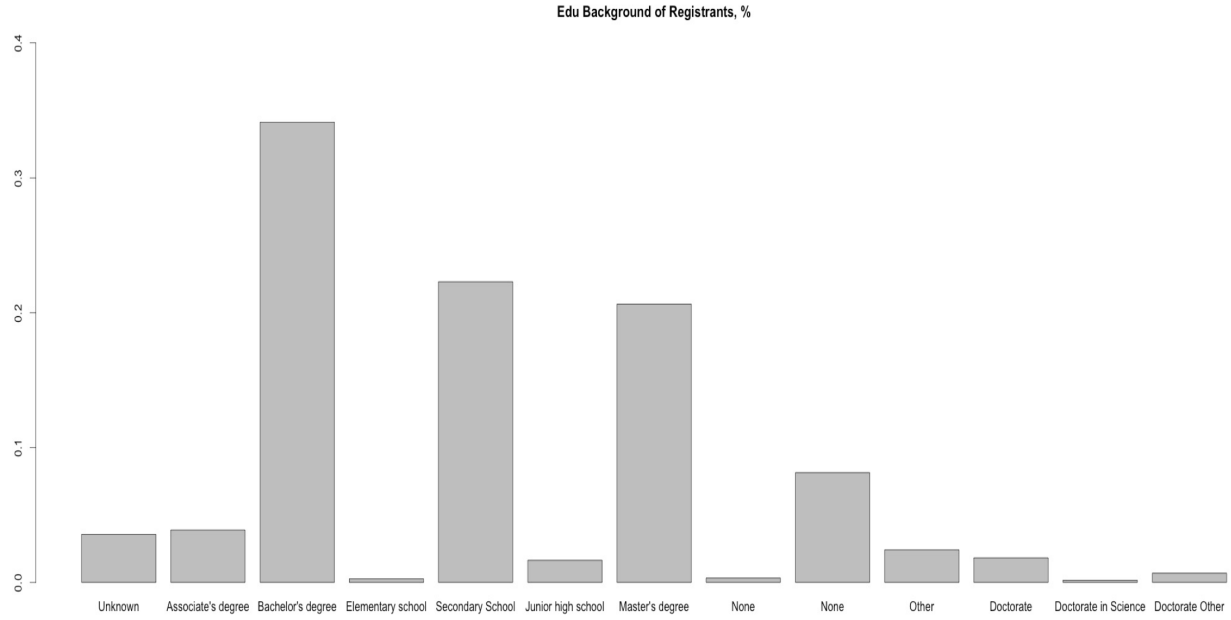
Appendix 1. Student Demographics

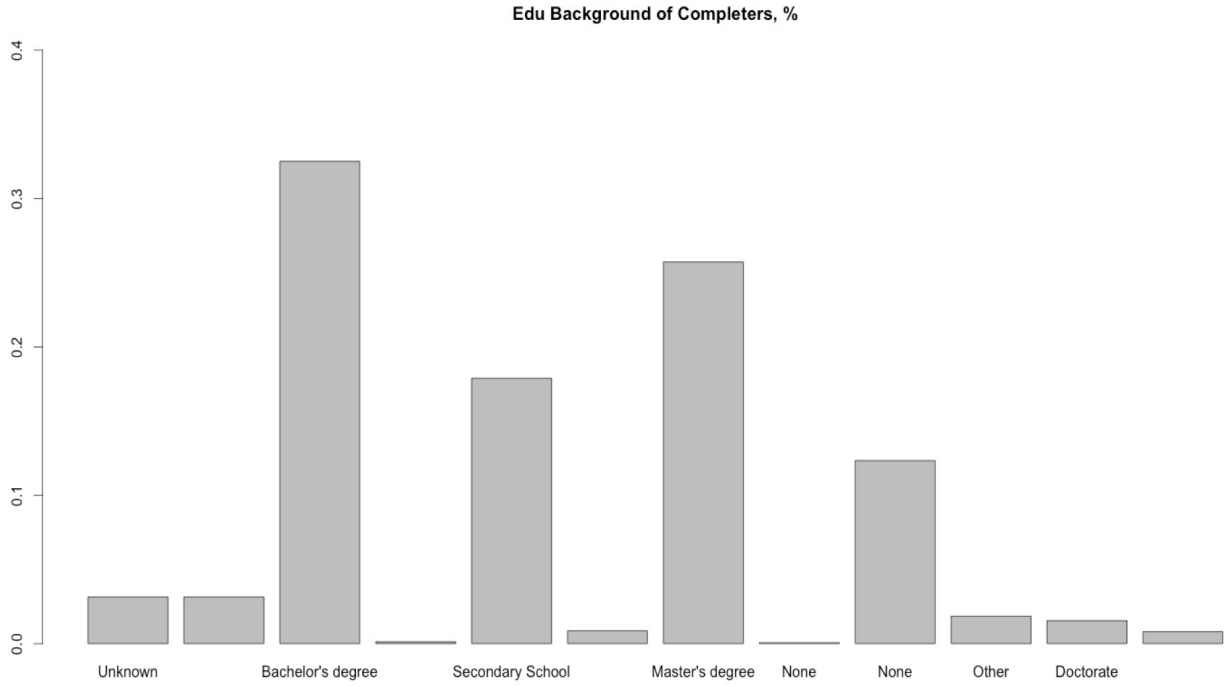
A) Age



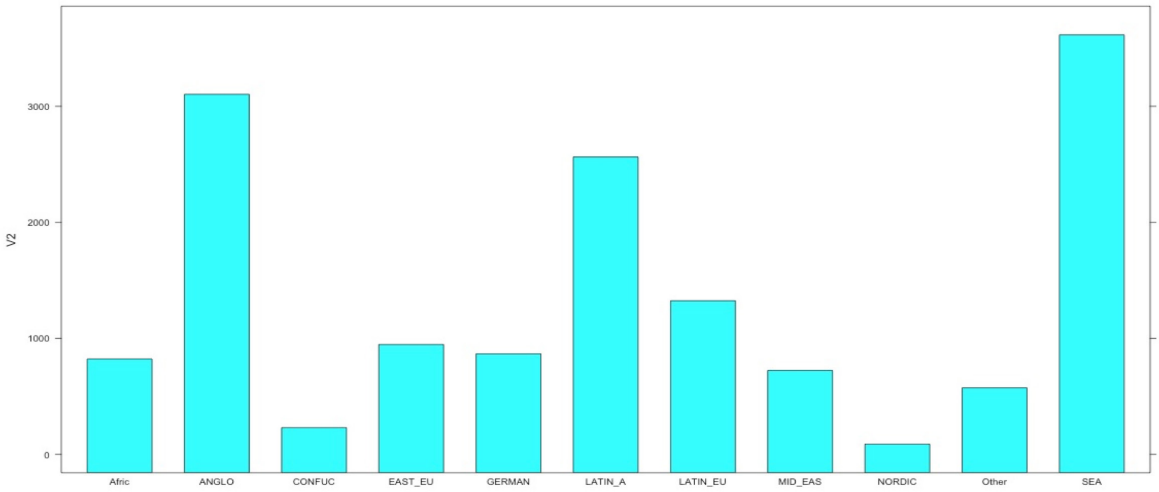


B) Educational Background

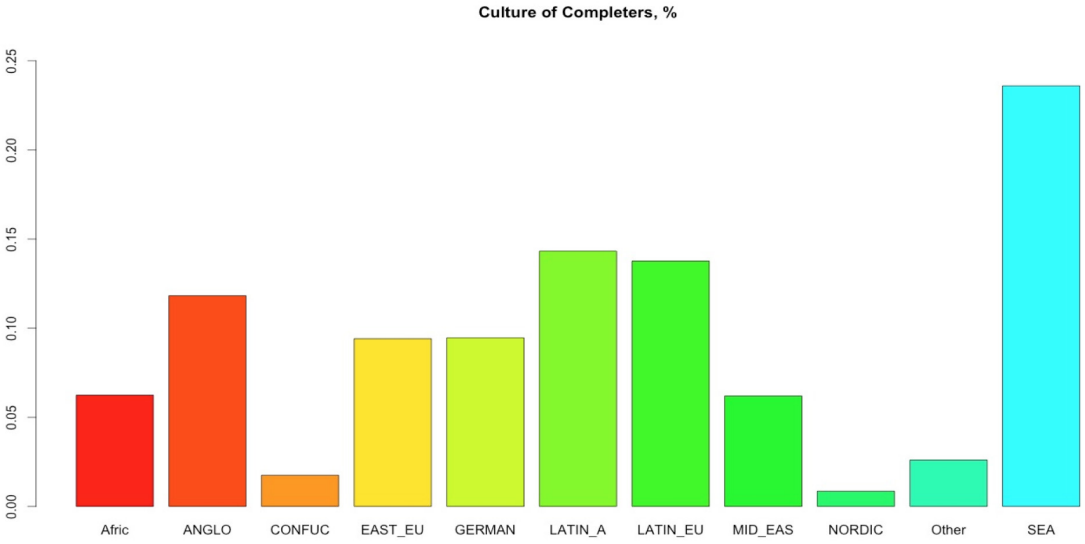




C) Cultural Background of Registrants

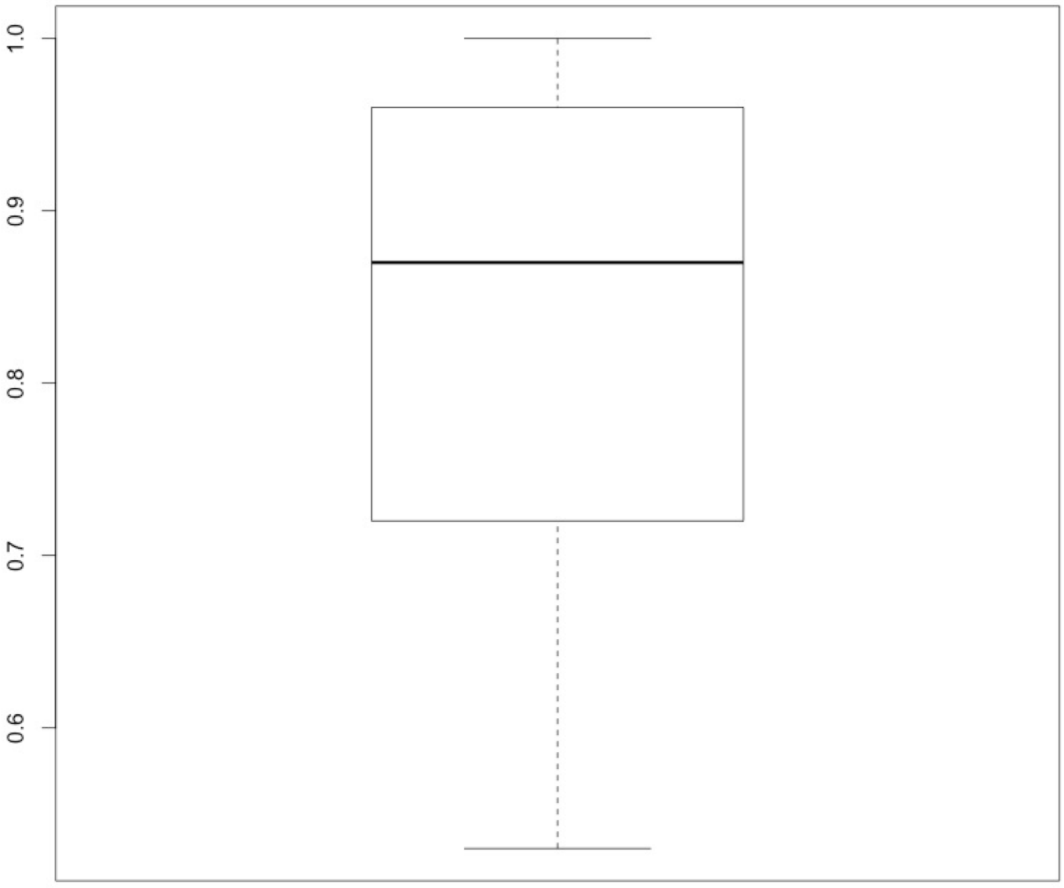


Cultural Background of Completers



Appendix 2. Course Performance

The passing grades from 0.53 to 1.0 are shown on the left side of the boxplot.
It can be seen from the boxplot that the average grade in the course is 89%; and that around 50% of the students scored over the average grade.



TU Delft Online Learning
Landbergstraat 15
2628 CE Delft
The Netherlands
http://online-learning.tudelft.nl
online-learning@tudelft.nl