Delft University of Technology

TU Delft Online Learning Research Working Paper #6

DelftX MOOCs, the First Year (2013-2014)

TU Delft

This report is a cross-course comparison of the first five DelftX MOOCs. In the working papers #1 - #5 you will find detailed descriptions of each of the courses.
The purpose of this analysis is to gain insight in the new opportunities and the new sources of data of this emerging online learning setting. The ultimate goal is to gain insights for enhancing DelftX educational provisions.

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ISBN: 9789461864611

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Acknowledgement

We would like to thank the MOOC participants, the 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, Stefano Bocconi, Pascal Gemke and Rick Slangen (TU Delft) for dealing with the data and helping us with the analysis.

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1. Introduction

This report is about the experiences with the first five MOOCs developed and executed at the Delft University of Technology (TUD) in the period 2013-2014. The aim is to describe and compare the MOOCs on the basis of user data and experiences including the insights from the teachers and developers. Since this was a first appraisal, the analysis was not implemented to proof any educational or political relevance, but to gather information for analytical purposes. The data were collected using different methods, including such diverse tools as statistical analysis of the systems data, social network analysis and interviews. More specifically, we included analysis of the subscription data from the participants, a pre- and post- survey, measured learning-related outcomes, i.e. performance and retention, interviews with teachers and developers, and the analysis of interaction in the forum and other media like Facebook. That being said, it should be reiterated that the analysis reported here are to be used and interpreted with caution, since the MOOC context is rather different from what higher education has experienced so far (DeBoer et al., 2014, Bayne et al., 2014).

The purpose of the analysis was to get a better insight in the development and performance of the 'xMOOCs", intended for large audiences, with the ultimate goal to support the stakeholders at Delft on all levels to make better (design) decisions. The stakeholders include:

- DelftX team working on a strategic level, involved in organizational issues, business and financial decisions
- Teachers and developers designing their courses, choosing media and instruments, organizing support
- New Media Center working on content design and production
- Evaluation team dealing with the monitoring and analysis applying an evaluation framework and accompanying instruments.

The focus in the analysis was on the one hand on the MOOC as a research object with the purpose to improve our understanding of (online) education as represented by the MOOCs. On the other hand, we aimed to better understand the opportunities the MOOC setting offers for research in course-related subjects: the MOOC as a research instrument. MOOCs attract people from all over the world, with very different cultural backgrounds, working experiences and as such are a great source. From experiences so far it is clear that MOOCs offer opportunities for high-quality research in a rather controlled environment with large numbers of participants from all ages and different locations. A bit of caution should be applied here though, because the term Massive is also to interpret as the massive variety of the student population and the kind of MOOCs, which makes it difficult to derive definitive conclusions despite the richness of the sources.

2013-2014 was the first year of TUD MOOC production and execution and a couple of issues need attention to learn and improve. As could be expected the stakeholders still have very different opinions about online and open education and the purpose (and future) of MOOCs. This coincides with a traditional on campus educational approach that, up until now, has dominated the MOOC development, but is expected to change when more experiences and examples become available. With the MOOCs there is a new data context, which contains lots of numbers, which not necessarily can be regarded for the underlying contribution to educational improvement. The university is confronted with a very different population of learners, which is demanding but enrich the university as a whole and in that sense post-hoc analyses, as applied here, are of great use to discover the working field of the MOOCs, but new lines of research are needed to develop strategies for the improvement of teaching and learning in such environments (Reich, 2014, Macleod et al., 2015)).

It is evident that at the TU Delft these first MOOCs have initiated not only a discussion, but also raised the awareness by teachers of the value of learning innovation and as such created a momentum that favors further development.

1.1. Why MOOCs and what to achieve?

The decision of the Delft University of Technology (TUD) to start with MOOCs was based on prior involvement and experiences with Open and Online Education. The TUD has been an active member of the Open Movement since 2007 (with over 130 courses published online through Open Courseware and iTunes University) and in that period developed a sense of importance for Open and Online Education. In 2013 the TUD joined the edX consortium, founded by MIT and Harvard University, with the intention to strengthen the presence in the field of open and online education. From 2012 on the TUD started a number of online master programs and blended learning initiatives and in September 2013 the first two MOOCs were launched on the edX platform, which were followed by three more in the spring of 2014.

This endeavor is discussed in detail in a strategy report from the TUD on the 'Next Phase of Open & Online Education' (Mulder, 2014), because Open and Online Education enters another level of development offering new opportunities to do experiments and research into what works online and how this can be used to increase the quality and effectiveness of on-campus education. This development is notoriously qualified as disruptive for the educational sector at large, underlining the need for a concerted action to develop a vision and an institute wide strategy to cope with the challenges and make it work (Christensen, 2010). The strategy is an intensive 2-year program in line with the Roadmap 2020 to expand and diversify the online portfolio, to innovate online didactics and campus pedagogy and strengthen the international collaboration in the field of education.

Part of this initiative is the formation of the O2E Research group (O2E = Open & Online Education), which organized the monitoring and analysis of what has happened with the MOOCs so far and how to improve the analysis and apply the lessons learned. From the start O2E has worked together with other university partners, also to develop an open research strategy. The experiences so far show that monitoring, analyzing and comparing your own MOOCs is very helpful to get a better understanding of what is happening, but it needs a wider range of research designs to develop a comprehensive insight in the factors that promote student learning. Data from many more courses are needed to conduct meaningful post-hoc comparisons of instructional approaches (Reich, 2014). Therefore open research is considered inevitable to achieve the goals of educational improvement as stated by our university. We define open research as the process of facilitating research activities.

1. …with relevant parties globally and locally
2. …on a broad range of relevant topics
3. …by giving them access to our data and research instruments
4. …and managing the collaboration workflow
5. …and publishing the results together, as research papers to the research community as well as actionable guidelines to our own teachers and support staff to improve courses.

1.2 What to expect in this report?

The focus is on the experiences with the first 5 MOOCs at the TU Delft with the emphasis on a post-hoc analysis. The MOOCs are compared where it seems useful and some interesting details came out due to some deeper digging and creative approaches of the pile of data. The variety of the MOOCs though on the level of subjects, didactical approaches, assignments, assessment or learning materials, makes it very unlikely to come to general conclusions concerning teaching and learning. Nevertheless there are some noteworthy details in this report concerning learner demographics, course pedagogy and social aspects of learning.

An overview of the courses at stake can be found in Table 1 of which some have a rerun in the season 2014-2015 and are used in addition to online courses, campus courses or in a mixed mode often in a flipped classroom format. They comprise a mix of topics, are generally based on existing campus courses, ran for six to eight weeks, attracted in total almost 140.000 registrants with a completion average of 3,7% and were all on bachelor level.

#1 ET3034TU Solar energy

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. 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.

#2 CTB3365 Introduction to Water Treatment

The course was designed as an introduction to water treatment systems on a bachelor's level with a focus on basic drinking water and wastewater treatment technologies for urban water services. It was structured in two long-lasting modules: drinking water and waste water. The course contained video lectures, convergent exercises, tests, and animations illustrating relevant engineering and physical phenomena. The assessment was focused on graded homework assignments and exams for corresponding modules.

Table 1. Overview of the first generation of DelftX MOOCs (2013-2014)

MOOCs	Period	#Students	# Completers	Level
#1 ET3034TU Solar energy	16.09 – 6.12.2013	57.091	2.730 (4,8%)	Bcs
#2 CTB3365 Introduction to Water Treatment	16.09 – 25.11.2013	29.088	545 (1,9%)	Bcs
#3 1110X Introduction to Aeronautical Engineering	03.03 – 19.5.2014	15.820	578 (3,7%)	Bcs
#4 TW3421 Credit Management	18.04 – 30.6.2014	20.925	709 (3,4%)	Bcs
#5 NGI101x Next Generation Infrastructures	23.04 – 8.7.2014	16.091	517 (3,2%)	Bcs
A total of		139.015	5.079 (3,7%)	

#3 1110X Introduction to Aeronautical Engineering

This course provided an overview of and introduction to the fundamentals of aeronautics, using examples from the very beginning of aviation. This trajectory started with a general introduction to aeronautics, to be followed by a closer look at aerodynamics and flight performance. The course was highly structured and teacher-controlled with frequent asynchronous student-teacher interaction. It followed a conventional format of several short video segment sandwiched with tasks comprising homework assignments. A separate communication space was dedicated for each task and lecture segment, providing easy structural access to ask a question or make a comment related to particular content. The assignments focused on engaging the students steadily and early on. Individual differences of the students are accommodated through materials that help student organize learning offline.

#4 TW3421 Credit Management

This course offered an introduction to credit risk modelling and hedging. The approach on credit risk is from the point of view of banks, but most of the tools and models we will overview can be beneficial at the corporate level as well.

The Credit MOOC (CREDIT) was a highly structured course in the area of applied non-life soft discipline. An important characteristic was the student-centered approach with frequent asynchronous student-teacher interactions. There was a significant number of supporting materials easing students way into understanding the core course content. The weekly course structure had a conventional format of short videos (under 10 min), few unassessed close-ended questions testing general comprehension, and extra reading or video resources reaching beyond the basics to present the diversity of opinions around the issue at the heart of the module.

#5 NGI101x Next Generation Infrastructures part 1

The course originated from the encompassing 10 year THE research program on New Generation Infrastructures, and covered the general discussion on infrastructural systems in the world with the purpose to develop a broad understanding. Most assignments revolved around authentic world-problems to provide a good balance between theory and examples. One of the achievements was the collective development of a World map on infrastructures, where students contributed with an array of materials.

The remainder of the report is the result of the analysis of the relatively new data context with a mix of systems data, survey results and interviews. The information is subdivided in a section on Learner demographics with issues like age and performance, gender, prior experience, cultural background and retention. The following section is about the Course pedagogy covering items like learning design, learner autonomy, and the use of the forum and assessment design. There is a section on the Social aspects of learning discussing the use of the forum by all students and by the completers, the nature of the social learning activities and the cultural preference for working with others or not. The analysis concludes with a summary review of the main issues mentioned by the students and the teachers when asked about their experiences while looking back. The final section of the report is on conclusions and considerations about future directions.

2. Learner Demographics

This section presents an overview of basic demographic characteristics. In some cases, we compare the demographics across courses, and in some cases we look at differences in groups in terms of grades or other performance metrics. In our analyses, we adopted different filters related with the students' final grades. For example, when we were interested in just completing students, we only included students with grade above .55. If, on the other hand, our interest was to approximate the population of students who have actually tried the course (rather than not even starting it), we included those with a grade above .10. When presenting a statistic or graph, all registered students are included in the analysis if not mentioned otherwise.

2.1. AGE

Figure 1 shows the age (median and spread) per course. It shows that CREDIT and NGI attract a more mature MOOC population, younger students in the SOLAR and WATER courses, and mostly students below 30 in the AERO MOOC. The average age, in all courses, is 30 or above.

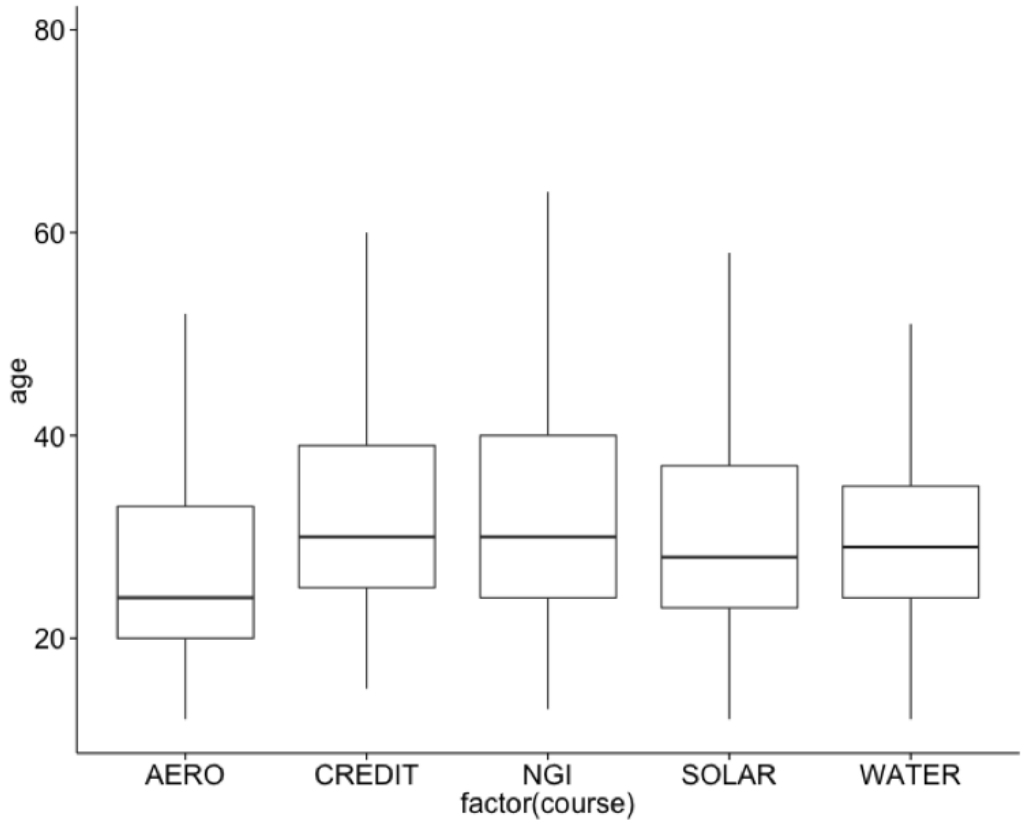


Figure 1. Boxplots showing the age (median + spread) per course

We wanted to know if performance was the same across different age groups. In order to answer this question, we conducted a t-test to compare means between younger (25 and younger) and older students. We included only students who have been at least minimally active by selecting only those with grade above 10. The independent samples t-test results show a statistical different mean grades, p = .000, between older students (.63) and younger students (.57), df=2757, t-value=7.8. We replicated this test for the individual courses, and only for CREDIT we do not see a significant difference (table 2).

Table 2. Mean grades young vs old (filter: grade>.10)

	Grade (>26)	Grade (12-25)	t-value	p-value	df
AERO	0.68	0.61	2.5	.01	282
CREDIT	0.68	0.73	-	-	-
NGI	0.63	0.55	2.0	.04	225
SOLAR	0.66	0.58	7.2	.000	739
WATER	0.48	0.43	2.9	.000	676
ALL	0.63	0.57	7.8	.000	2757

We also looked at this statistic from the other side: is there an age difference between completers (above .53) and non-completers (below .53)? We ran another t-test and this age difference seemed to be the case only in the courses SOLAR and WATER (the largest datasets), with $p < .000$ resp. $p < .01$. The illustration below shows how age and completion are related in all five MOOCs. NGI, AERO, and CREDIT have higher completion scores than WATER and SOLAR.

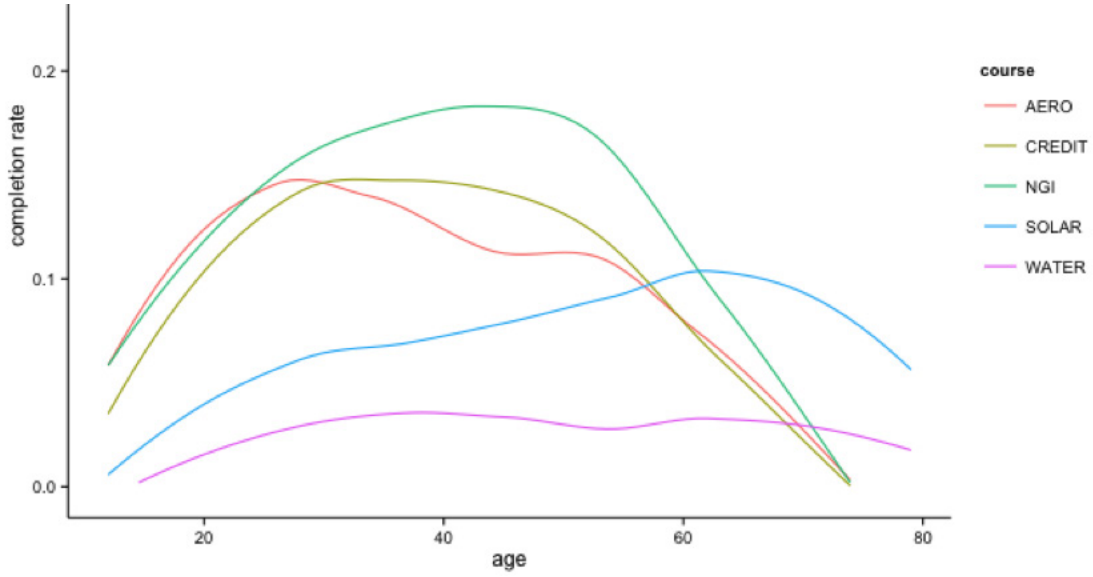


Figure 2. Completion rate per age.

Because a significant portion of MOOC learners can be considered 'adult learners', we were interested in possible differences between older and younger students. One approach we took was to look at performance indicators. Figure 3 shows the distribution of grades for both young (25 and below) and older students (above 26 years). Learners who have not started a single assessment were removed from the data set. It shows spikes around grade 0.6 (passing grade), which is especially strong for the younger student population. The plot for older participants has a more steady distribution, but clearly increases around the grades close to 1.0. One of the ways of interpreting these patterns is to assume that there are varying attitudes that characterize these two sub-populations: 'a performance orientation' and a 'mastery orientation' (Elliot & Dweck 1988). In contrast to 'mastery orientation', people with a 'performance orientation' believe that success is the result of superior ability and of surpassing one's peers, and are often driven by a desire to outperform others and demonstrate their ability (Senko and Harackiewicz 2002). Older students may be more interested in learning than a particular grade or certificate: the distribution of grades is more equal. Also, in line with the above analyses, older students seem to have less difficulty in getting a higher grade.

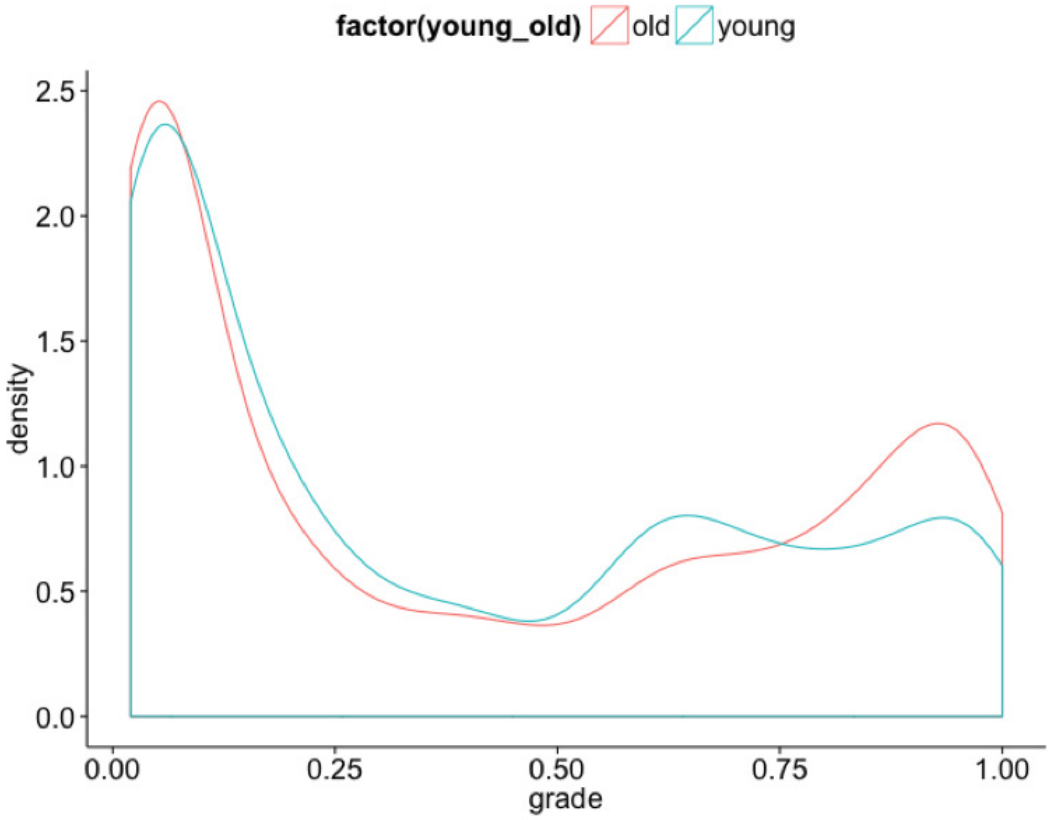


Figure 3. Grade density plot (filter: grade>.01)

To gain some insights into whether these hypotheses are relevant, additional inquiry was done in the student motivations to take the course, as reported in pre-course surveys. One of the default answers in pre-course surveys was "I would like to get a certificate for successful completion". When compared the mean age between students who were motivated by a certificate, and those who were not, the age difference across all courses is significant (p=.000), with an average age difference of 3.9 years between those motivated by the certificate of completion and those who are not. The table below shows the statistics for all courses. This seems to support the interpretation that the certificate of completion is more important for younger students than for older students.

Table 3. Welch t-test age ~ "Reason for starting this course: Certificate"

	AERO	CREDIT	NGI	SOLAR	WATER
df	1713	1889	1596	2530	1888
t	9.8	8.6	7.3	12.2	7.2
p	.000	.000	.000	.000	.000
mean (no cert)	31.6	35.2	34.8	34.4	33.8
mean (cert)	26.2	31.1	30.9	30.9	31.4
95% conf	4.3	3.2	2.9	2.9	1.7
int	6.5	5.0	5.0	4.0	3.0

2.2. GENDER

The ratio of female students entering engineering courses is generally low (Jordan et al., 2013; MacLeod et al., 2015). One of the things we noticed when investigating the different courses, was a slightly lower relative completion rate for female student as compared to male students. The table below shows the female student ratio per course and overall for all students and only completing students. It clearly shows a higher 'dropout' of female students across all courses. Further analysis showed that age did not seem to influence this, and neither was the higher attrition rate caused by early dropout, but happened throughout the course. Also, we looked at self-reported belonging and perceived enjoyment of the course, and although female students did not report as much sense of belonging or enjoyment, this difference was not statistically significant.

Table 4. Male-female student ration start vs end of course (N = 65.596)

	ALL	AERO	CREDIT	NGI	SOLAR	WATER
Registered students (f)	19%	14%	21%	21%	15%	26%
Completing students (f)	15%	12%	17%	13%	12%	25%

When we looked more closely, we saw that female students, in all courses, are younger than male students. In line with that, we see less and less female students in the older age groups, as can be seen in the stacked bar chart below.

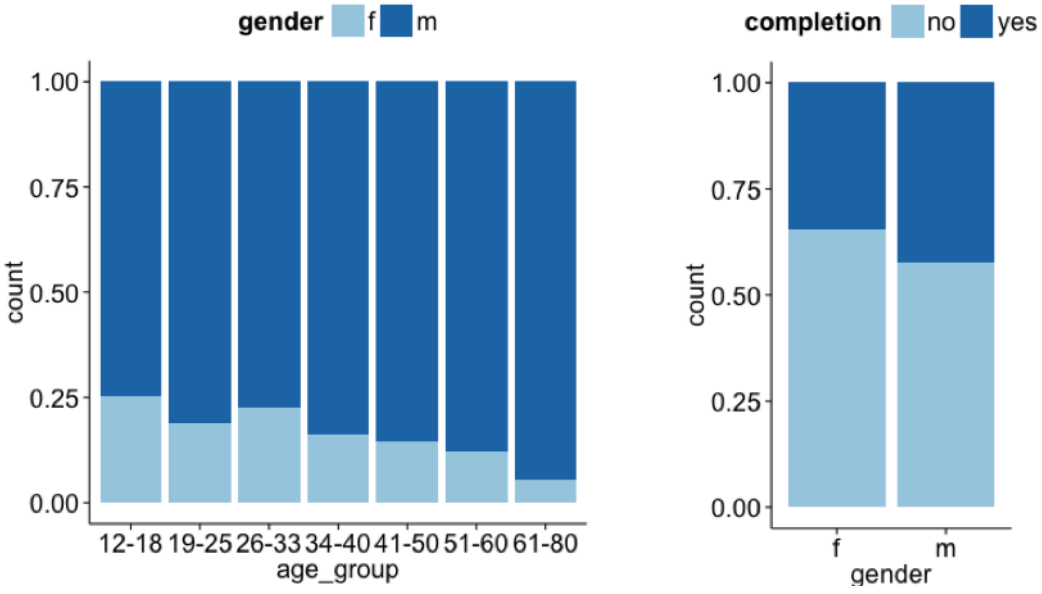


Figure 4. Gender distribution across age groups & completion rate (grade > .01)

Likewise, we also see a lower performance (grade and completion) among female students. Excluding students who have not attempted any graded assessment (grade>.01), we do see a significant difference in average grade between male and female students: .36 vs .42, $t(2753) = -7.3$, $p=.000$. In addition, we see a lower completion rate, clearly shown in the second chart in Figure 4.

The earlier hypothesized 'performance orientation' (see: Figure 3) can be seen in the Figure 5 below as well: it can be hypothesized that male students are more motivated by obtaining a certificate of completion than female students, as we saw with younger students versus older students.

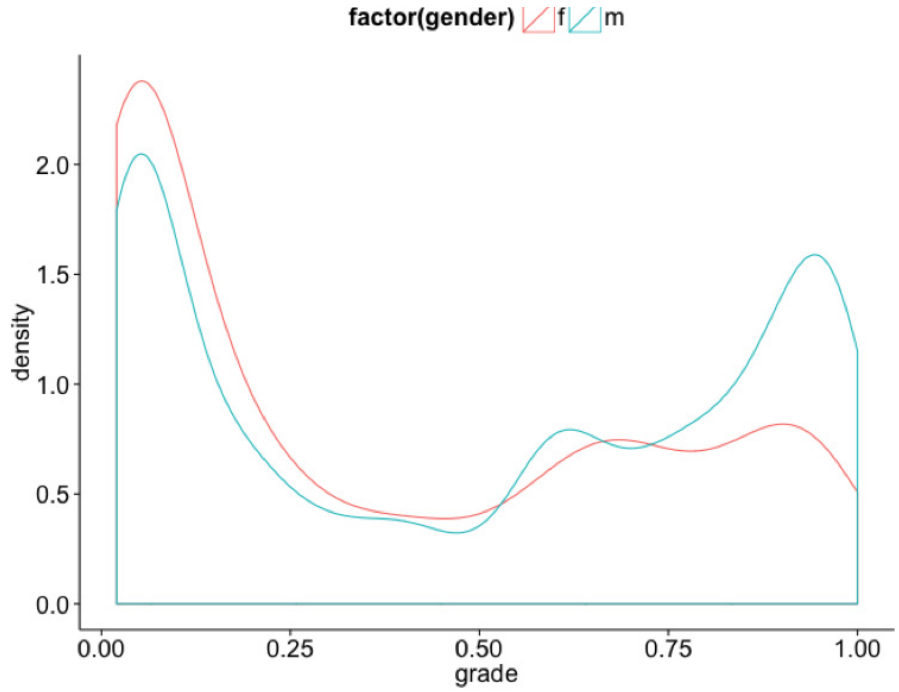


Figure 5. Gender - grade density plot (filter: grade>.01)

In conclusion, we do see quite significant differences in performance and demographic factors between male and female students across all MOOCs. In addition, we see a low registration and participation rate of female students in technical MOOCs, which is a known issue. These and other matters related with gender are currently under investigation in other DelftX MOOCs.

2.3. EDUCATION LEVEL

The dominant level of education in the 5 MOOCs was a bachelor's degree. The NGI and CREDIT MOOCs attracted students with a higher level of education; half of the students who registered for the CREDIT MOOC had at least a master degree. The table below shows the distribution of level of education per MOOC.

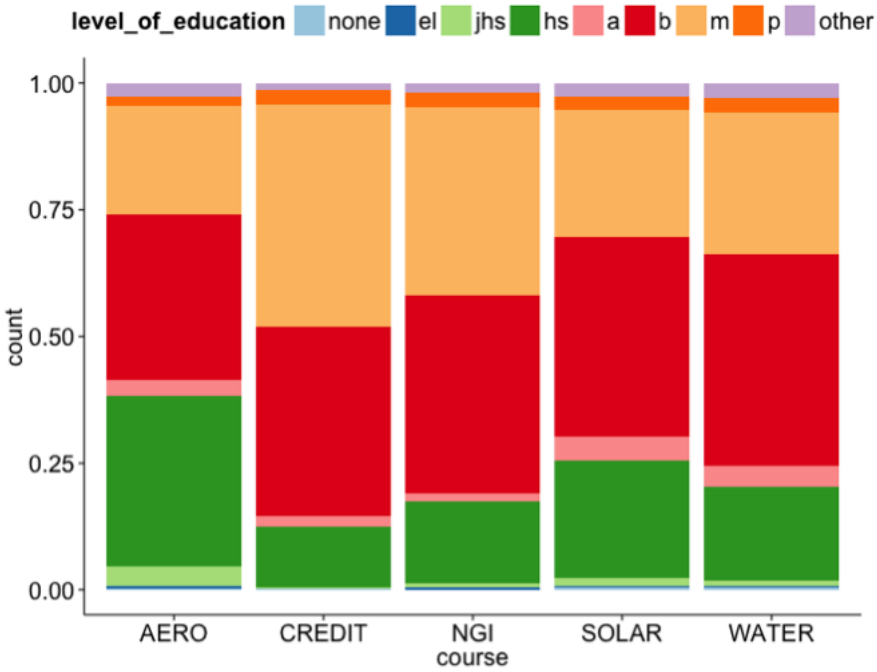


Figure 6. Education levels for different courses

The completion rate is higher among higher-educated students than among lower educated students, which may not be surprising. On average, bachelor students comprise 40% of the students; this percentage is the same among completing students as well as non-completing students. This balance shifts when you look at the other levels of education: lower levels of education have a relative lower percentage of completers versus non-completers. Only the NGI MOOC is different in this respect: it is the only course where the relative percentage of completers with a master degree is lower than non-completing students with a master degree. In other words, the average level of education of completing students is lower than the level of registered students.
In line with the above, we observe higher performance (grades) among students with a higher level of education (Figure 7). Through a simple regression analysis, we examined a possible relation between level of education and performance across all courses. The results can be seen in the boxplots below, showing the grades on y-axis and variance of the most dominant levels of education: high-school (1), bachelor (2), and master's degree (3). The plot also contains the regression line, with an intercept of .34 and a slope of .07 (p=0.004).

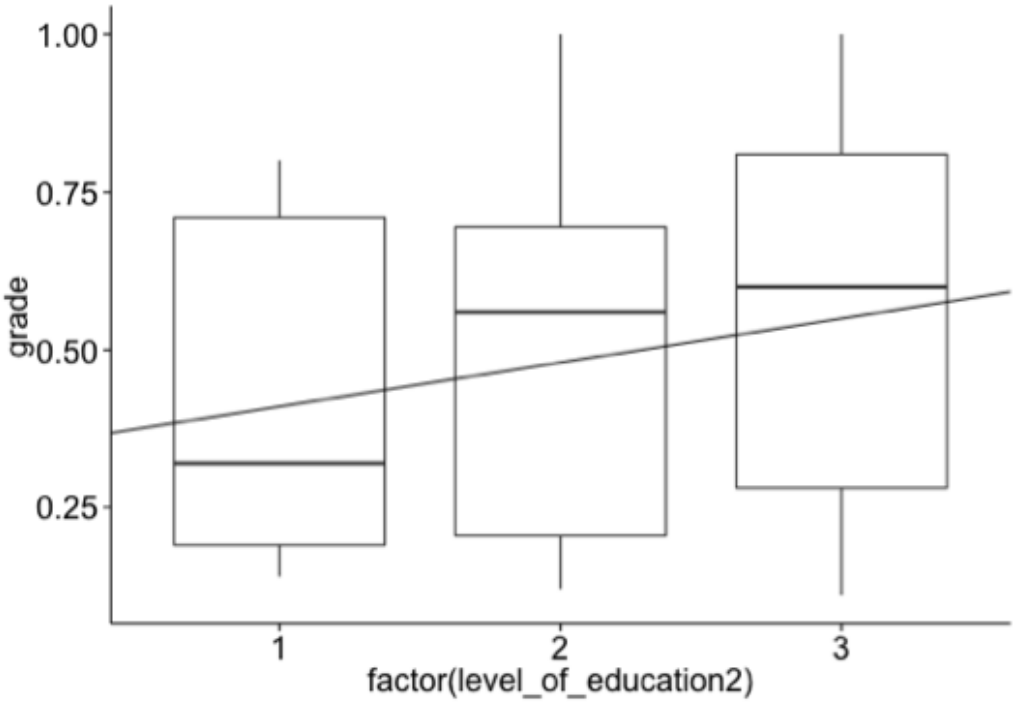


Figure 7. Boxplot and regression line for grade ~ level of education (grade>.10)

2.4. PRIOR EXPERIENCE

For different reasons, it is relevant to know about the students' background and in particular their relation to the course topic. Is having a background in the topic helpful in completing the course? And how many students do have a background in the course? Surprisingly, we don't see any evidence that prior experience has any effect on performance. However, we do see significant results when we look at early dropout or non-starting the course. Table 5 below shows clearly that – when taking the entire population (including those who have not started) – the mean grades increase with level of prior experience. On the other hand, when we only look at those students with grade above .10 (those who have done one or more graded assignments), there is no significant difference correlation of prior experience and grade.

Table 5. Correlation statistics for prior experience ~ grade (filter: all vs grade>.10)

	filter:	grade>.1	grade >.1	All	All students
course		mean	cor	mean	cor
AERO	No prior experience	0.65	no	0.19	cor = .09
	Same/similar level experience	0.64		0.23	t = 3.3477, df = 1348
	More advanced experience	0.75		0.27	p-value = 0.001
CREDIT	No prior experience	0.72	no	0.16	cor=.08
	Same/similar level experience	0.67		0.19	t = 3.3505, df = 1604
	More advanced experience	0.73		0.29	p-value = .001
NGI	No prior experience	0.62	no	0.24	cor = .06
	Same/similar level experience	0.63		0.28	t = 1.9199, df = 1178
	More advanced experience	0.63		0.30	p-value = 0.055
SOLAR	No prior experience	0.68	no	0.20	cor = .13
	Same/similar level experience	0.71		0.29	t = 5.9084, df = 2026
	More advanced experience	0.69		0.22	p-value = .000
WATER	No prior experience	0.52	no	0.10	cor = .16

This would mean that more experienced students are more likely to continue or persevere during the course, and that those who do not have prior experience more easily drop out early in the course. The graph below also shows that among the low-achievers (grade < .10) there is a relative high ratio of inexperienced students, while among the medium and higher achievers, there is no such distinction. This may indicate that prior experience is a predictor for early dropout.

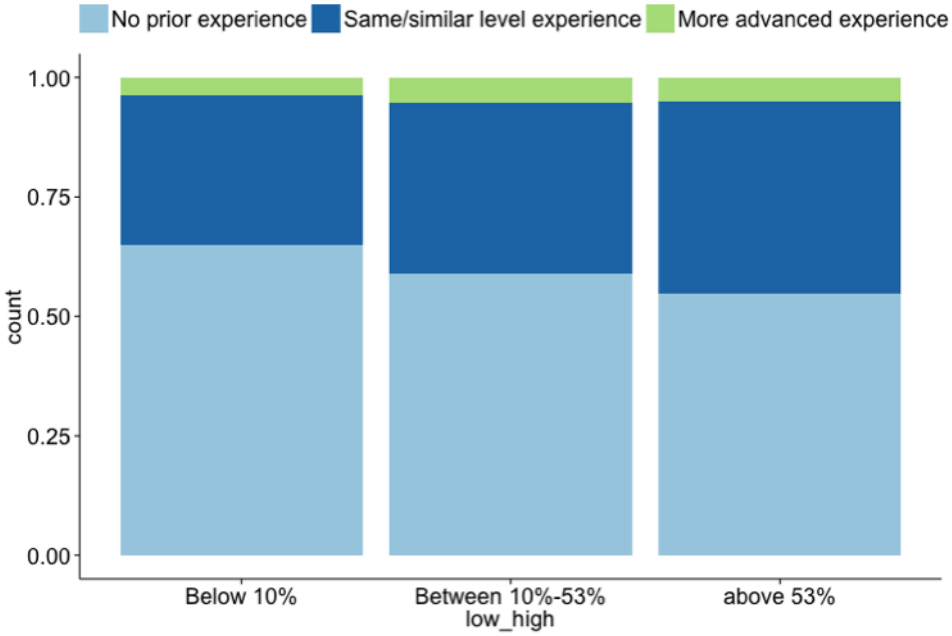


Figure 8. Prior experience and grade (n=13864)

In addition to prior experience in the topic, we asked students how many online courses they have done before. An independent t-samples t-test was used to verify the difference in mean grades between inexperienced students (less than 2 online courses done) and experienced students (2 or more online courses done). There was a significant grade difference between inexperienced students (mean=.65) and experienced students (mean=.69), t(1853)=2,8, p=.006.

2.5. CULTURAL BACKGROUND

Cultural values shape learning behaviors and experience, and research on cultural differences and their effects on learners and learning environments shows that pedagogical methods and structure may not be equally effective (Hofstede, 1986; Sweeney, Weaven, & Herington, 2008). In order to uncover the role of culture on performance and other variables, we have grouped countries of origin into cultural clusters, in accordance with GLOBE Extension Study (Mensah & Chen, 2013). Clustering is statistically derived and accounts for such factors as (1) racial/ethnic distribution; (2) religious distribution; (3) geographic proximity of the countries; (4) major language distribution; and (5) colonial heritage.

Several major clusters are distinguished:

- Africa
- Latin Europe
- Latin America
- East Europe (includes some South European countries)
- Germanic
- Nordic (includes the Baltic countries)
- South East Asia
- Confucian Asia
- Middle East
- Anglo (mostly English-speaking countries)

The image below visualizes the distribution of the different cultural groups across the various MOOCs.

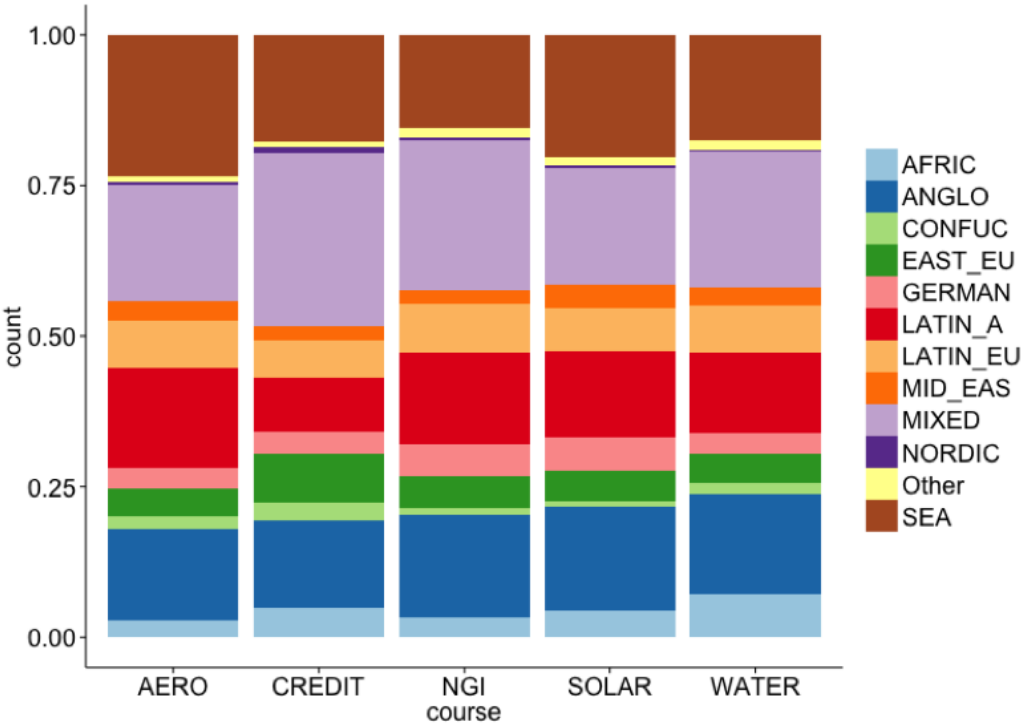


Figure 9. Cultural clusters across MOOCs

Cultural clustering provides an analytical framework that relates to understanding learners expectations towards the role of the teacher (i.e. their relationship with power), their expectations towards peer-to-peer interaction, and other factors related to course satisfaction, experience of the learning process and community development. Further research into correlating cultural preferences with other variables may provide more insights as to how to accommodate to the international online classroom. In an upcoming section on 'Social Aspects of Online Learning' we discuss the topic of preferences of working with other students during the course versus the reality of collaboration between MOOC students.

We have registered students from 172 countries in the world. In other words: they are from everywhere. The most dominant countries were India and the United States, and many Latin(-American) countries, including Spain, Brazil, and Mexico. The top 10 nationalities per course are shown in the table below.

Table 6. Top-10 nationalities per course

All		SOLAR		WATER		AERO		CREDIT		NGI	
India	2598	India	1411	India	427	India	306	India	288	India	166
United States	2043	United States	1147	United States	425	United States	147	United States	168	United States	156
Spain	902	Netherlands	526	Spain	223	Spain	93	Brazil	60	Brazil	93
Netherlands	774	Spain	448	Netherlands	126	Brazil	88	Spain	56	Spain	82
Brazil	678	Brazil	317	Nigeria	123	Mexico	77	Italy	48	Netherlands	47
Mexico	514	Mexico	269	Brazil	120	Colombia	52	Nigeria	45	United Kingdom	33
Colombia	461	Colombia	248	Mexico	105	Netherlands	38	Canada	43	Colombia	32
Nigeria	407	Pakistan	235	Colombia	97	Pakistan	32	Greece	38	Mexico	30
Pakistan	381	Nigeria	183	Philippines	84	Greece	32	Netherlands	37	Greece	29
United Kingdom	343	United Kingdom	181	United Kingdom	72	Canada	31	Mexico	33	Nigeria	26

3. Retention

Retention across the first generation of DelftX MOOCs is shown through an operationalized measure that captures the drop of participation for those learners who demonstrated strong intention to engage in formal credentialing. According to Figure 10, the difference between the numbers of learners engaged in the first assessed activity and the number of learners engaged in the last assessed activity, fluctuates from 19% - 76%. Within this sub-group of learners, the first high drop of participation occurs after they attempt the first homework. Further waves of dropping out seem to depend on the design of assessment design, and values assigned to homework assignments and exams.

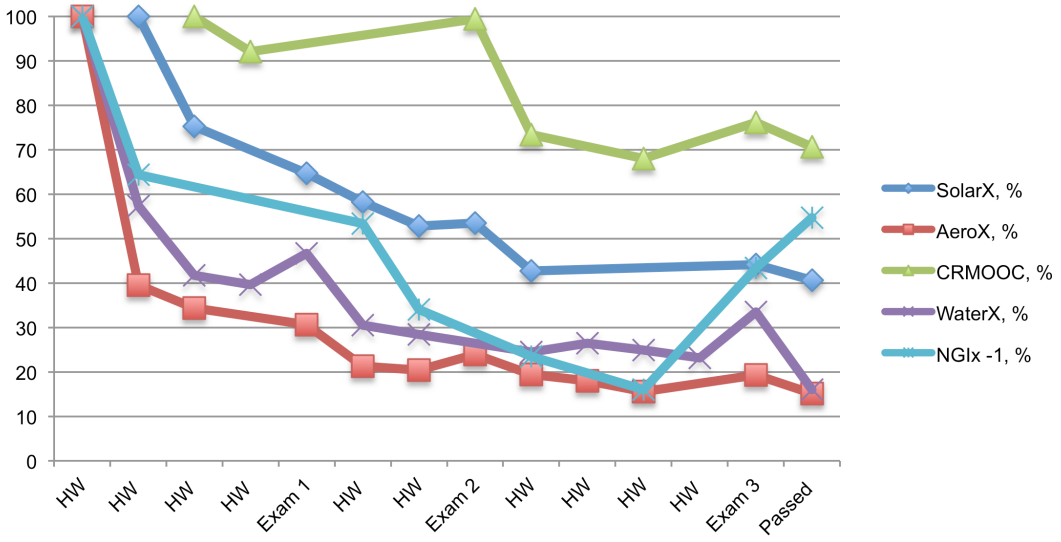


Figure 10. Retention across the first generation of DelftX MOOCs

Our decision to conceptualize the group of those with strong intention to complete the course through graded assessments is based on the observation that 95% of all completing students show their intention to receive formal credentialing early in the course through attempting the first assessed homework task. More specifically, the total number of completing students across all five courses is 5244, out of which 4964 students attempted the first homework.

Figure 10 illustrates the relative retention, where the number of the students attempting the first homework is treated as 100%. Not all graded assignments are given out in the first week of the course. For example, first two graded assignments in AERO were released within the same very first week, while the very first assignment in CREDIT was released in the third week of the course. The deadlines when these assignments were due also differ significantly, and are not address through the graph.

The graph shows that the highest drop of the number of students occurs between the attempt of the first and the second homework. This may indicate that learners adjust their expectations in relation to the course difficulty and decide to quit formal credentialing. Although the number of assessment points differs, it does not seem to influence the curve. There is always higher number of people attempting exams than attempting homework, while the number of those who receive a "Pass" grade is close to the number of students who attempted homework tasks. NGIx had 6 entry points for assessment, where it was sufficient for the learners to complete three only, along with the final one. We can see that learners preferred to engage with earlier homework tasks more than with the later ones. Finally, there is always a drop after the exam takes place.

By adopting an operationalized measure for assessing student retention, it can be said that highest retention rate, i.e. 74% of the students who attempted the first graded assignments persevered and also attempted the last exam, was observed in the course with high student autonomy, high learning support, slightly lower workload and high individual feedback from the teacher. However, it should be noted that the first assessment in this course took place in week 3. Had the instructor offered earlier assessment, it is quite possible that then the graphical representation may have captured a larger drop in participation.

4. Pedagogy

The focus of this section is to position the retention numbers of the first generation of DelftX MOOXs into the pedagogical context within which they have occurred. This section sets to pedagogically contextualize the data obtained from the first generation of DelftX MOOCs. Providing deep analysis of why certain decisions were adopted is beyond the scope of the paper.

Pedagogical decisions around the first generation of DelftX MOOCs (Table 7) are diverse, and not a single MOOC is the same. Courses all differ along the aspects of analysis, such as learning design, academic disciplines, the degree of teacher's control and learner autonomy, decisions towards social aspects of learning, e.g. forum placement in the courseware, or forum facilitation strategies, and finally, assessment design. We strongly advise the researchers using data from these courses to make careful interpretations of the data as these emerged in very distinct pedagogical contexts.

4.1. Learning Design

All five MOOCs differed in learning design as demonstrated through the visual representation of learning resources. Table 7 represents the ratio between types of course resources, such as content, i.e. video lectures, demonstrations, readings, tutorials, etc.; assessment, i.e. graded assignments; organizational support, i.e. course announcements, syllabi, calendar with deadlines, as well as formula sheets; discussion, i.e. number of sub-forums; feedback, i.e. group-level video-recorded feedback; unassessed quizzes, i.e. ungraded practice and comprehension tasks; learning support, i.e. elements explicitly linked to quality instructional principles, such as clearly stated objectives, as well as content replication in the form of foreshadowing, summaries, or similar. The volume of the types of resources is not comparable across the courses, e.g. NGIx has the biggest chunk of content, and that implies its relative size to other types of activities within the same course, not its relative size to the amount of content in other courses. To give some idea of the content volume, the average suggested/ reported workload as well as the amount of video footage is also specified for each course. Additionally, the amount of personalized teacher/ staff feedback provided at the course forum was excluded from the representations. The approach was inspired by Open University's Learning Design Initiative[1], and MOOC learning representations (Weller, 2014).

[1] http://www.open.ac.uk/blogs/OULDI/

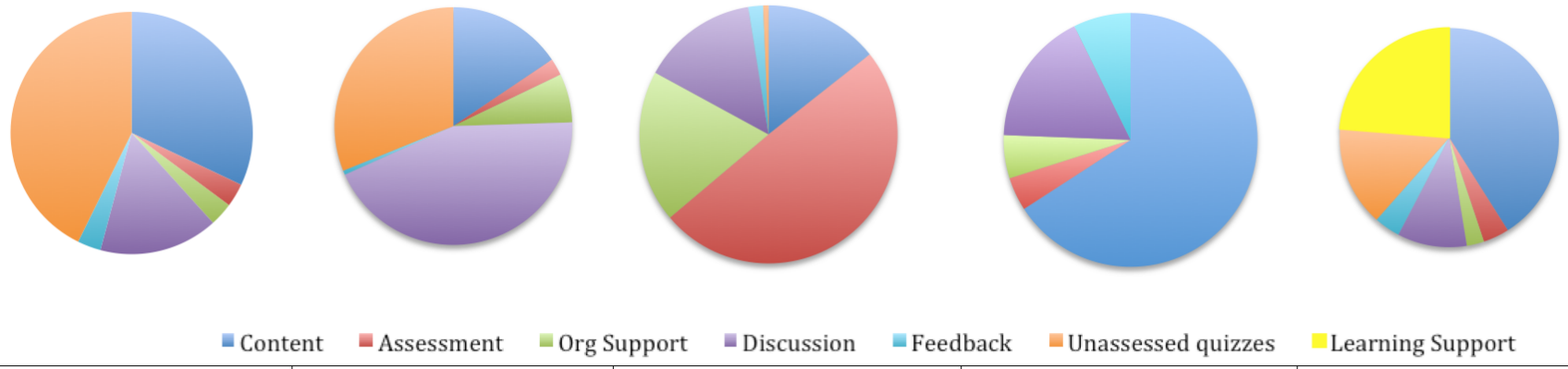
WaterX	SolarX	AeroX	NGIx – 1	CREDIT
				
Applied non-life/ Pure non-life hard sciences Moderate Teacher Control Partially embedded forum Moderate individual feedback Workload: 10-12 hrs/w Assessment: - 80% - two exams - 20% - ten homework tasks Passing Grade: 60% Retention, 33.44% (1st HW to last HW) Average Grade: 71,94%	Applied non-life/ Pure non-life hard sciences Moderate Teacher Control Fully embedded forum High individual feedback, Community TAs Workload: 8 hrs/w Video Content: 9,92 hours Assessment - 60% - three exams - 40% - 5 homework tasks Passing grade: 53% Retention, 44 % (1st HW to last HW) Average Grade: 99%	Applied non-life/ Pure non-life hard sciences High teacher control Fully embedded forum Very high individual feedback Workload: 10-12 hrs/w Video Content: 14,5 hrs Assessment - 40% - Module 1 (75% - Test + 25% - HW tasks) - 30% - Module 2 (75% - Test + 25% - HW tasks) - 30% - Module 3 (75% - Test + 25% - HW tasks) Passing Grade: 55% Retention, 19% (1st HW to last HW) Average Grade: 76%	Applied non-life soft sciences Low teacher control Partially embedded forum Low individual feedback, Community TA Workload: 6 - 8 hrs/w Video content: 10 hrs Assessment - 60% - regular homework tasks (3-6) - 40% - final paper - Open-ended tasks Passing Grade: 60% (Based on peer assessment) Retention, 43% (1st HW to last HW) Average grade: 93%	Applied non-life soft sciences Low teacher control Non-embedded forum High individual feedback Workload: 6,5 hrs Video content: 4,7 hrs Assessment: - 80% - two exams - 20% - four homework tasks Passing grade: 50% Retention - 76% (1st HW to final exam) Average Grade: 80%

Table 7. Overview of the First Generation DelftX MOOCs, 2013-2014

4.2. Academic Discipline

SolarX, WaterX and AeroX can be classified as courses within applied non-life hard sciences (engineering elements) and Pure non-life hard sciences (physics elements). NGIx and CRM are defined as within applied non-life soft sciences.

Although both NGIx and CRM had elements of applied non-life hard sciences (computer science and mathematics), due to overall pedagogical framing of the content and learning outcomes within these two courses, it was viewed as secondary. Course classification was adopted from Biglan (1973; Toven-Lindsey, Rhoads, & Lozano, 2014).

4.3. Teacher Control and Learner Autonomy

DelftX MOOCs of the first generation varied in the degree of control exercised by teachers, and degree of autonomy provided to the students.

AEROx was delivered and designed as highly teacher-controlled course, while CRM and NGIx are to be found on the opposite end of this continuum, with highest levels of learner autonomy. WaterX and SolarX had elements of moderate teacher control. Such factors as content release (weekly/ all at once); flexibility of deadlines; learner's choice of the content, embeddedness and convergent nature of assessment was taken into account. All these were extreme in AeroX: modules released weekly, strict deadlines, assessment forcing to engage with activities regularly and early on, if the student is interested in certification, convergent nature of assessment and no choice of content. CRM on the other hand, had all the content released at once, had one deadline for all assignments – the end of the course, and allowed learners to democratically elect last week's content. Tasks were still convergent. NGIx, similarly, exercised teacher control through on-going homework deadlines, but allowed learner autonomy in the choice of subject for their open-ended tasks, in the number of tasks submitted, as well as it was the only course undertaking peer-based assessment. The analysis of these elements was heavily informed by the pedagogical framework developed by Swan et al. (2014).

4.4. Forum placement and strategies

Distinct strategies to support social learning activities taking place on edX forum were adopted within DelftX MOOCs, differing in a) where the forum were positioned within the course; b) who provided individualized feedback on the forum; c) how often individualized feedback was provided. These choices provide contexts for the comparison of volume of forum interactions (Table 7).

The structure and positioning of edX forum within DelftX courses varied, where discussion threads were fully or partially integrated into, or excluded from the learning content. In both cases of full or partial integration of the forum with course content, the learners could still create new threads at the actual discussion forum, it is just that there were also given numerous shortcuts to getting to the forum directly from the content that may have caused the need to connect with peers or teachers. WaterX and NGIx 1- partially embedded forum into the course content, i.e. at the end of weekly modules. SolarX and AeroX fully embedded forum into the course's content, with a discussion space under each component, e.g. web-lecture, assessed quiz, unassessed task, reading, etc. would be followed by discussion space within the same web-page. Finally, CRM placed forum completely outside of the course's content, splitting weekly forum threads into two: one with questions for the teacher, and one with questions for the learner.

Multiple approaches to the provision of individualized feedback were adopted within the first generation of DelftX MOOCs. WaterX adopted a moderate individualized feedback strategy: a few comments from staff early in the course were given to ensure precise communication of practicalities, which then shifted towards "laissez-faire" strategy, i.e. staff regularly scanned the forum and collected impressions for weekly group-level feedback, without actually providing any feedback to the students on the forum. Similar strategy was adopted by NGIx -1, however, staff individual feedback was more of motivational than informational nature. Moreover, NGIx -1 sought help from student community Teaching Assistants (TAs) recruited from the student body. SolarX, CRM and AeroX, had staff and teachers actively involved in providing a lot of individualized feedback. Among the courses with high individual feedback strategies, SolarX additionally engaged active community teaching assistants recruited from the student body.

The degree of feedback also varied and is relational between the five analyzed courses, as specified in the Table 7.

4.5. Assessment Design

Teachers of the first generation of MOOCs applied varying designs for their assessment activities, ranging from strict and controlled nested assessment strategies to loose forms of peer assessment, or open deadline policies. Such contextual factors are relevant for analyses of student engagement and retention, as well as understanding the differences between student grades across the courses.

Comparison of assessment design was done around the issues of teacher and learner control over how and when students were assessed, and did not analyze how assignments and exams addressed knowledge representation and competence development within a specific domain.

All the courses were different in their assessment strategies. WaterX and CRM used the 80/20 principle, allowing learners to only take exams to pass the course (80% of the grade), but also giving the choice to influence the final grade through on-going weekly assignments (20% of the grade). The difference between these two courses was that CRM had an open deadline policy, allowing learners to take exams at any time during the course. SolarX took on a similar approach but assigned slightly lower values to exams, and slightly higher values to homework tasks, actually allowing learners to receive credentialing even if they pass only one exam, but complete homework. NGIx – 1 was the only course with open-ended questions on the topics chosen by learners, but also completely peer-assessed. AeroX is the example of highly controlled assessment, requiring learners to complete on-going homework tasks and exams, within strictly given week for that purpose.

5. Social Aspects of Learning

This section describes observations related to the aspects of social learning in the first generation of DelftX MOOCs.

Only few students participate in the forums. Level of activity across courses differs and is found higher in courses where the forum is integrated with courseware (e.g. some of the forum threads positioned under the video segments), the number of tasks is higher, as well as the teaching presence is stronger. We have seen higher activity among not very active students in the courses where extremely active students show less activity. The nature of social activity in three courses that we have analyzed resembles that of crowd-sourced learning. Two types of sub-communities are observed: a) the ones that are more static without fostering interconnections, and emerging around a theme; b) the ones that are more dynamic, overtime fostering some interconnections, and emerging around a person with a teaching function. Finally, cultural preferences for social learning has been found to differ: for English-speaking students, students of Germanic culture, and Eastern Europe tend to prefer to work alone, while students from South East Asia, Middle East and African cultures show higher preference to work together with others. Generally, South East Asian students tend to be less vocal on the forums, while English-speaking and Germanic students tend to be more vocal on the forums. However, analysis of more courses with similar demographic composition of completion and similar course design are needed to provide any solid conclusions on this matter.

5.1. Level of Activity

Analysis of social learning activity described in the Working Paper has been limited to edX forums. Forum sizes varied from a 5000 posts up to over 20 000. Courses with higher teaching control and feedback on the forums (e.g. SolarX and AeroX) appeared to have a higher volume of activity. These two courses also have higher number of tasks as a part of the course. It has been observed that usually students engaging on the forums are discussing solutions or confusions related to the tasks (both graded and ungraded). We did not pursue statistical analysis of these relationships but inquiring into forum conditions and social learning activity across a larger number of courses within the same disciplinary field may provide an additional insight.

In line with reported information from other MOOC forums, only a small percentage of the entire student body participated in the course discussions. Overview of the forum data presents the general involvement in social learning activity across the courses (Table 8).

Table 8. Use of edX Forum by all registered students

Course	WaterX, %, (n)	SolarX, %, (n)	AeroX, %, (n)	NGIx, % (n)	CREDIT, % (n)
Forum-related Features	Partially embedded forum Moderate individual feedback Higher number of tasks	Fully embedded forum High individual feedback, Community TAs Higher number of tasks	Fully embedded forum Very high individual feedback Higher number of tasks	Partially embedded forum Low individual feedback, Community TA Lower number of tasks	Non-embedded forum High individual feedback Lower number of tasks
Superposters (50-700 posts per person)	0.06 (18)	0.06 (33)	0.19 (30)	0.04 (7)	0,01 (3)
Very active (30-49 posts per person)	0.13 (39)	0.05 (30)	0.17 (27)	0.11 (18)	0,02 (4)
Active (15-29 posts per person)	0.4 (118)	0.17 (96)	0.38 (60)	0.33 (54)	0,005 (10)
Moderately active (7-14 posts per person)	0.97 (283)	0.47 (269)	0.94 (149)	0.8 (129)	0,24 (51)
Inactive (4-6 posts per person)	1.25 (366)	0.71 (405)	0.97 (153)	0.91 (147)	0,38 (80)
Passive (1-3 posts per person)	5.00 (1466)	3.75 (2139)	4.73 (748)	3,5 (570)	2.00 (429)
Did not post (0 posts)	6.56 (1922)	5.67 (3236)	7.6 (1202)	5.15 (829)	3.89 (814)
Never logged in the forum	85 (25076)	89 (50833)	85.03 (13451)	89.1 (14337)	93.4 (19534)

Overview of social learning involvement by completing students shows that overall students with intention to receive formal certification were more likely to engage in class discussions (Table 8).

For the analyzed three cases, in courses with less involved forum facilitation, students with Super-posting behavior (more than 50 posts) showed lower activity than Super-posting students in courses with higher involvement of teachers or student assistants. For example, a Super-poster in courses with higher teacher's involvement (and higher number of tasks) would produce around 1000 posts, while in course with lower teacher's involvement in the forum, the number of posts made by top users is under 300 posts.

Courses that demonstrate higher ratio of completing students making more posts on the forum are the ones where a more "laissez faire" strategy was adopted towards student-run discussions, i.e. forums were closely monitored, and reflected upon in weekly videos, but direct forum posting by staff was minimal and only, if strictly necessary. For example, in WATER and NGIx, the percentage of students making 15 -29 posts is 8%. This observation only applies to the ratios across courses, but not to the number of students participating (due to the different sizes of the courses).

The simple explanation for higher activity from non-Superposting students when there is lower Superposting activity, could be that when very active students show less activity, more opportunities are created for others to step into discussions. Prior research, however, has shown that Superposting activity does not influence that health of the forum (Huang, Dasgupta, Ghosh, Manning, & Sanders, 2014). Further research may need to focus on defining "healthy" as opposed to "democratic" forums to clarify these issues of participation.

Table 9. Use of edX Forum by the students who received the certificate of completion

	WaterX, %, (n)	SolarX, %, (n)	AeroX, %, (n)	NGIx , % (n)	CREDIT, % (n)
Superposters (50-700 posts per person)	2.20 (12)	1.03 (30)	3.43 (26)	1.35 (7)	0,4 (3)
Very active (30-49 posts per person)	3.30 (18)	0.93 (27)	3.16 (24)	3.1 (16)	0,4 (3)
Active (15-29 posts per person)	8.44 (46)	2.71 (79)	5.67 (43)	8.7 (45)	0,8 (6)
Moderately active (7-14 posts per person)	16.15 (88)	6.15 (179)	10.3 (78)	16.83 (87)	3,2 (23)
Inactive (4-6 posts per person)	12.11 (66)	7.31 (213)	6.60 (50)	16.25 (84)	5 (36)
Passive (1-3 posts per person)	21.10 (115)	18.92 (551)	12.66 (96)	28.05 (145)	13,6 (97)
Did not post (0 posts)	13.58 (74)	15.76 (459)	11.21 (85)	6 (31)	14.25 (101)
Never logged in the forum	23.12 (126)	47.18 (1374)	46.97 (356)	19.72 (102)	62 (440)

5.2. Social Network Structure of Forum Discussions

To gain deeper insights into the structures of interactions between the students, we have constructed social networks of forum interactions in three MOOCs: AeroX, NGIx, and CREDIT. Directed time-based graphs represented the communication flow: if A posted, and B replied, an edge between the two was created. The three courses have similar structures underpinning the flow of peer-to-peer and peer-to-teacher interactions, characterized by a long-tail distribution, i.e. few people posted a lot, and many people posted little. Additionally, although the teacher involvement in these three courses was slightly different, those who fulfill the teaching function (staff, teachers or community assistants recruited from the student body) maintained their positioning at the center of the course' networks regardless of the course.

5.3. Cultural Preferences for Working with Others

When analyzing differences and preferences of learners towards information sharing, engaging with other learners, forum participation and collaboration, we decided to consider a demographic that has been addressed but scarcely covered in MOOC research, i.e. the cultures from which the students come from.

The discussion of culturally-appropriate online pedagogies includes understanding which learners behaviors are culturally determined (Parrish & Linder-VanBerschot, 2010). The cultural differences in relation to learning can be found in three dimensions, which represent learner perspectives on social relationships, epistemological beliefs and temporal perspectives (ibid.).

To understand whether there is a tendency for a culturally determined preference for engaging with others while learning in the MOOC, we analysed how belonging to a culture may be linked to students' preference to work alone on a course, or together with another student.

Pre-course questionnaires included questions on learners' nationality, current residency, and the country where they received their latest degree. It was done to highlight that understanding the cultural preference of the learner who may have been born in India, is significantly shaped by either the academic culture or host country culture, this same learner could have adopted in, for example, the US. In such a situation, the learners' cluster would be changed from South-East Asia to the English-speaking cluster.

We also used a Mixed Culture Cluster to account for the students who may have been significantly influenced by cultures other than his/her own. In pre-course questionnaire of two MOOCs (WaterX and SolarX), the students were asked about their nationality, country of residence, and where they received their education. If all the three countries belonged to the same cluster, then the learner was assigned that cultural cluster. If the answers to these three questions belonged to different culture clusters, then the learner was assigned the Mixed culture cluster, with the assumption, that it is not up to us to decide which one is more prominent. The majority of students within the Mixed Culture Cluster were born various places and either lived or studied in Anglo or Germanic culture. The third prevalent group in the Mixed cluster was Latin Americans who either lived or studied in Latin European countries

The answers of the pre-course questionnaire as to whether individual learners preferred to work on this course alone, or together with another student, were combined with culture clusters. As reflected in table 10, although the entire students body preferences are split 50:50, there seems to be a tendency among cultures to prefer working alone or together, which implies that culture does play a role in how learners engage with one another.

There are striking differences when it comes to certain cultural groups, such as African, Middle Eastern or South East Asian who show stronger preference towards working with another student. Similarly, cultures like Anglo, Germanic and Eastern European show a tendency to the preference of working alone. Mixed group shows the ratio that reflects the general tendency, i.e. 50:50. Unfortunately, the Nordic group in both courses is too small to draw any conclusions (<20 people), and the Confucian group shows difference in between two courses (but still a slight preference to working with others during the course). Because the other results were very comparable, we show the combined results of both courses below in Figure 11.

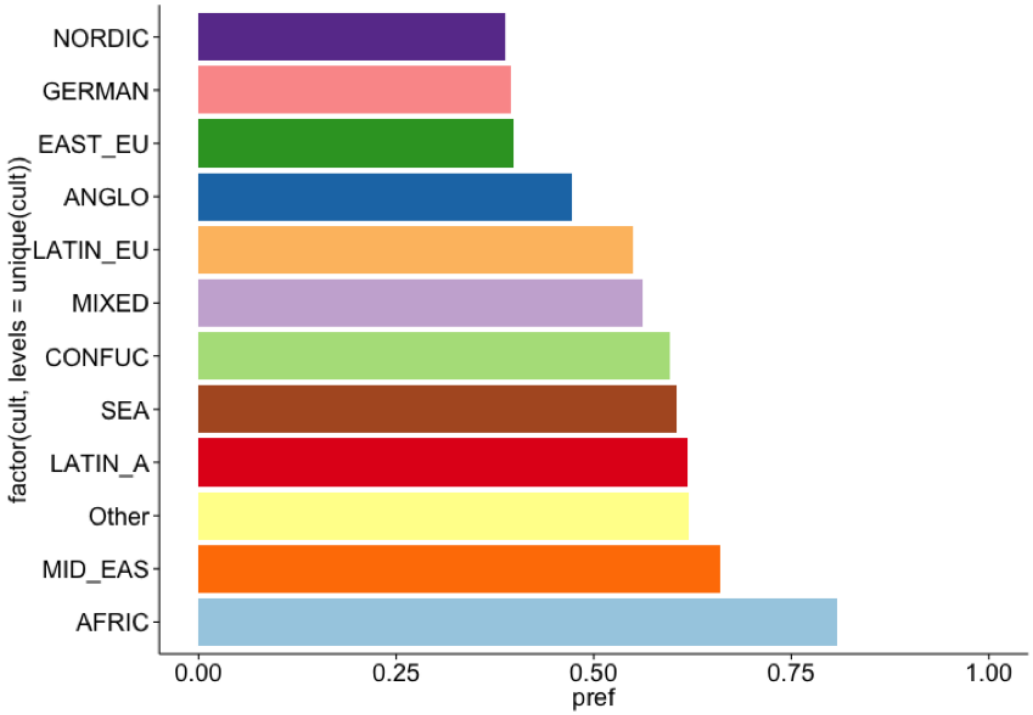


Figure 11. Preference to working with others per cultural group (measured for courses SOLAR and WATER)

6. Looking back

A pre- and post-course survey for students and a pre- and post-course interview with the teachers and developers of the course allowed us to collect some qualitative information on the experiences of the participants. 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 survey's also zoomed in on issues, beyond the already discussed topics on demography, retention and the social aspects of learning, 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 if such a course inspired them to continue learning. In all cases, be aware of the fact that the large majority of the students who filled in the post-course survey presumably were completers, so the review is biased, but still worth looking at.

6.1. The student view

Overall the students were very confident (80% +) that they could handle the requirements and were rather determined to finish the course (80% +) and pass the examination (80% +). They also believed that working harder would help them to achieve more (60%+). When it comes to social interaction, most indicated (50%+) that they would have wanted to connect with other students more than they did. This would than include experience sharing, giving or receiving help and the use of the course forum. The participation in the course forum shows a pattern that is more or less equally spread from no participation (20%+), rarely (30%), sometimes (30%), often (10%), to all the time (5%). So there is something to gain when it comes to social interaction and this is confirmed by the reactions on the questions concerning online participation. It is only a small percentage (10% +) that joined a study group or made friends. A larger group (40% +) contacted the instructor or teaching assistant for support or looked for extra materials (80% +).

In general the students as participant in the course felt rather well. A clear majority (80%+) suggested that they had a feeling of belonging and believed that the course instructors cared about their learning experience (80%+). So, no wonder that a good 90%+ of the students said that they really enjoyed the course or courses.

Especially the experiences in the first few weeks made clear that students face all kinds of challenges to continue with the course of which lack of time seems to be the most important reason, but also health and the political environment played a role in the decision to stop. Some mentioned that they were bothered by a slow internet or electricity problems, but the majority had no such complications. As time is an important issue, students felt during the course a little (31%) or somewhat stressful (34%), but felt quite in control of things (80% +) and perceived that things turned out well (80%+).

Important for the justification of participation are the expectations. A clear majority (70%+) of the students said that their expectations about the course were realistic. This is also shown in the fact that 60% believed that the course exceeded their expectations and 36% found that the course was exactly what they expected. The overall quality of the course was rated good to very good (97%). Also the overall quality of assignments and exams, the balance between lectures and exercises and the feedback were rated good to very good (90%), but with some flaws were rather new peer review technics were introduced and partly not well understood.

Most students (70%+) would like to do another course by the same team of teachers and this positive perspective apparently also spurred the appreciation for the TU Delft (positive 80%+). This did not mean though that everybody wanted to apply for an online graduate program (absolutely 20+%, probably 15%+ and maybe 25%). Nonetheless the courses inspired most of the students (absolutely 60%+), to continue studying in the field of their course and this is good news, because this is one of the objectives why the TU started the MOOCs, namely opening up opportunities for those who might otherwise not be able to acquire new knowledge and insights in their particular fields.

6.2. The view of the other stakeholders

This is not just about teachers, it also includes the views of other stakeholders who were directly involved in the process of developing and deploying the MOOCs. The consultation of the different stake holders was to collect in this early stage of MOOC development the opinions and perspectives of those involved. In our institution it is known that the early adopters of MOOCs are very motivated, but have different reasons for spending their time and energy on developing and executing a MOOC. Their understanding and considerations are important for the development of a sustainable framework that supports online and open education in general, but in this case MOOC expansion in particular.

The interviews were aimed to record issues that were considered important by the stakeholders on a strategic, tactical and operational level of the MOOCs that were developed and executed in the season 2013-2014. The following procedure was used for the interviews:

- Interview with the stakeholders who were directly involved (the teachers, developers, New Media Centre developers, the Open and Online Learning 'activists' and the DelftX team) who were all closely involved in the development and/or the execution of the MOOC.
- The interview took place at the start of the MOOC and after the MOOC was done. A semi-structured interview format was used to guide the conversation. The main topics discussed were: first impressions; objectives; course design; strengths, weaknesses and challenges; tasks and responsibilities; future developments.

For the preparation of the interviews several resources were used: the submitted proposal of the teachers to acquire support for their MOOC, the insights gained while monitoring the development and implementation of the MOOC and the available user data at that stage. The intention of the interviews was to collect perspectives, expectations and experiences at an early moment in the process of 'doing a MOOC'. And then at the end of the process, with the evaluation results at hand, talk again. The interviews were also used to gather the opinion of the stakeholders concerning the future of MOOCs: practice in multiple situations, reused and applied differently in other online and blended learning contexts.

Next a summary of findings starting with the motivation for doing a MOOC, the main experiences as perceived by the different parties followed by some more detailed findings

6.3. The view of the other stakeholders

The primary goal of most teachers was:

- To make education available for everyone.
- To expose themselves to the world as experts, in order to become an authority in the field by delivering a high quality course that reflects the quality of the on campus education,
- The marketing for Master courses and to develop a test case for the online Master programs,
- The usage of MOOC material in on campus education and improve on campus education,
- Use MOOC experiences to get more of an insight in a possible business model for MOOC enhanced regular education,
- The MOOC as a perfect opportunity to learn more about the learning behavior of student in an online environment
- To learn more about the learning preferences of students and how to align online education with these preferences.
- To learn about opportunities to extend subject matter research to the community of participants using crowd sourcing techniques
- To do large scale domain-independent experiments that inherently could supply answers to interesting questions

6.4. First experiences

There was no MOOC design process available as a 'How to?" which made it initially impossible to make a realistic time planning. So the biggest challenge for the developers was the very high time pressure due to uncertainties in the coordination, production time, agendas and other organizational practices. They qualified their pioneer role as very exciting, inspiring and challenging. It was a learning process for everybody and certainly the positive reactions of the students during the first weeks were experienced by the developers as very satisfying for their hard work.

For most people online learning was a rather new activity and a MOOC adds to the complexity of this process. The time pressure is obviously related to the fact that so many new things had to be developed in a rather short period of time. This included: new pedagogical design, design decisions, videos, scripts, animations, simulations, assignments, questions, communication with DelftX, and others. This process of co-creation, working together on the same product, affected the decision-making process, required a highly demanding coordination and suffered also from misalignment between the expectations of the participants, which is rather normal for such a first time product. In the first stage almost all people involved expressed their wish for a MOOC design guide. This guide should contain a stepwise guideline of tasks, an overview of functions and a time planning for making a MOOC, and should help future developers to make a detailed and realistic workflow for the entire development

process.

Teachers, developers and students showed a rather good spirit, being very enthusiastic about this endeavor. There were some worries about the gap between the number of registrants at the beginning and the number of persistent participants after the first two weeks following the official start of the MOOC. The term 'dropouts' seems not applicable for these students, since they all have a very different reason to subscribe (curious, just looking, try it out, etc.), which is declared by the openness and accessibility of the MOOC course. It is clear that the diversity in age, location, schooling, living conditions, intention, expectation, etc. are very different and therefor demanding and calling for a different mindset from the developers and teachers. Some felt that this new online learning context put them in the role of 'the teacher as a learning architect 'much more than in regular education.

Most teachers found the idea exciting to have better opportunities to 'read' the learner more than before. The data collected are promising, but still need some work to make those more meaningful and useful in the hands of the teacher, who has a clear preference for real time solutions to be able to make timely interventions. The heterogeneity of the participants, the subject and the learning approaches as such, allow for not domain specific data to be collected and compared, as has been done in this report, but the domain specific analysis is needed to collect meaningful information on the learning activities and learning process that is taking place.

Time pressure continued to be high as some activities could not be finished ahead of time, so obviously there was a continuous challenging planning scheme, that should seriously be looked at to increase the feasibility of making the development and execution of a MOOC workable. This also comprises the communication and interaction with DelftX management, the New Media Center and others, which in the long run could certainly be improved. The New Media Centre service model evolved in the course of the year into: 'We do it for you, with you or do it yourself'. The goal is to establish a 'do-it-yourself pillar' as the way to go, but not without the appropriate training facilities and further professionalization of the organization.

6.5. Challenges and problems

Clearly the biggest issues are time related and certainly also quality related. Not having enough time to test the questions, try out the assignments, etc. due to the uncertainties in the production process. The need for additional coordination, changing responsibilities, lack of capacity and structure and the experience of somehow bureaucratic procedures with too long communication lines and too many people. These are the day-to-day realities in doing such a new thing as building and executing a MOOC. At the same time the teachers were not negatively affected, became creative in finding solutions and became also more realistic about the opportunities and limitations.

What stayed high on the list was a 'How to MOOC' book or source. In the early stage the demand was for 'hands-on tips and tricks' to get going. Later on this shifted to the demand for guidelines and suggestions for learning design principles that should help to avoid all kinds of problems that might arise due to lack of knowledge, experiences and coordination. Teachers became very much aware of the fact that learning science was in demand also to build trust in the value of the design for learning efficiency. As a result there was a need for background information on the edX organization, the opportunities to gather information on experiences from elsewhere, to have more teaching related examples.

The edX platform worked well, but was not really user friendly which caused some flaws on the usability of the forum and on a more detailed level showed to be less useful for interaction; the possibilities for editing all aspects of the course were limited; internal links to exams and questions were poor, the instructor's dashboard needed an upgrade and edX should offer mobile apps and allow for a better integration of social networks in the platform. In the course of the year some of these flaws have been improved, but the forum still lacks the user friendliness you would expect for such a system. It is unclear though if the lack of forum participation and mutual collaboration, as experienced by the teacher and as shown by the user data, can be explained by the forum affordances.

6.6. Lessons learned

- One of the lessons was on how to respond to relevant online questions posed by students in the MOOC. The solutions were diverse, ranging from extra student assistants to additional weekly compressed video messages.
- Another lesson was the need to really test the questions and exercises beforehand. It is not that easy to have

'good questions' and certainly without the opportunity to proof and test it is a tricky venture and might create negative reviews.
- Rather new was the experience with crowdsourcing and using the contribution from the thousands of MOOC participants (responses to questions, video's, pictures and other materials) as a course resource and as an additional resource for domain specific research.
- The opportunity to adapt the 'learning strategy' using data-analysis seems a very good option to really improve the course using the user data as a source for change. This will take some more time to make this work in daily practice.
- The continuing uncertainty of the teachers and developers about the design of the lectures, the content and media selection, the duration of the video, the appropriateness of the lay-out. In short the design principles are often not strong enough or lacking and there is a need for additional guidelines to enable teachers to create engaging online courses.

6.7. Strengths

- After the initial flaws, many problems tend to dissolve due to the creativity of the people involved who learned how to cope with it, find other solutions, ignore the disturbances and started to value the changes made on the go by management and others.
- The content was quickly appreciated as a good basis for other learning contexts like blended learning and online courses.
- Although the data-analytics still needs to be developed for real-time use and accommodation, the opportunity to better 'read' the learner was welcomed, as well as the opportunity to use the forum data for research on how well certain design decisions are being appreciated and valued for their impact on learning results.
- The MOOC evokes high motivation among the people involved and it was admitted that doing a MOOC made teachers rethink their teaching and helped a lot to reshape their standard classes. There is a general feeling that MOOCs provoke the innovation of education.
- It seems that the MOOC students are 'high achievers' from around the world, but they are rather 'unknown learners' and the diversity feels like there must be a lack of alignment that certainly affects the quality and the student capacity to learn.

Questions that emerged touched on the relation between educational data mining and learning analytics and the capacity to use this information to improve the teaching and learning strategy for better performance. Issues mentioned were: the dropout rate; the alignment of teaching and learning activities with the target group; questions about motivation, engagement; feedback and assessment arrangements; the opportunities for experiments in the MOOC setting using A/B testing and other. Working with such a dispersed crowd demands a clear policy on privacy and ethics. Next to all the enjoyment of working on a MOOC the question raised was about the return on effort. Can we afford such an investment in time and money and how sustainable is it?

7. Conclusions and Future Direction

This report is about the experiences with the first five MOOCs at the Delft University of Technology in the period 2013-2014. Two of these MOOCs already experienced a rerun in a somewhat different format and most MOOCs have had their impact on the campus courses. The expectation is that in the summer of 2015 the TUD will have experienced a total of nineteen MOOCs. So, clearly the MOOC story is an ongoing development favored by an increasing number of teachers and developers. In addition MOOC materials are gradually being used in campus education for online degree courses, blended learning settings and formats like the flipped classroom.

MOOCs not only evoke different modes of teaching and learning, but allow for additional research while involving the crowd of students as an important source. Also MOOCs function as mechanisms to improve collaboration and exchange and to meet new research partners. It is unclear how this story will end, so we still have to deal with assumptions and predictions, but the fact is that education gets more attention than ever before and it seems we still have to get used to that.

Our findings from the analysis and comparison of the DelftX MOOCs offer some interesting insights in the rapidly changing area of online higher education. Our focus was on the learner, because who are these tens of thousands who sign up and what do they want to achieve?

What we know is that:

- Students come from everywhere, but most students come from India and the US.
- The average age of the students in all MOOCs is 30 or above.
- The younger ones seem to be more motivated by clear markers of performance (certificate of completion) and the older ones more interested in just learning.
- The number of female students is low in all courses; they are generally younger than male students and are more likely to drop out early on in the course, also their overall performance (grades) is lower than male students.
- Students without prior experience are more likely to drop out early on in the course.

What about Retention?

- Students who have done more than 1 online course before score significantly higher than students who never did any online course.
- Only in 2 courses, the students' level of education correlates with a higher grade.
- 'Getting a certificate of completion' is a significantly more important reason for signing up among younger students.
- This difference in intention also translates back to a different learning behavior during the course: younger students (<25 yrs) are more often motivated by markers of achievement than older students.
- Prior experience does not seem to predict higher grades either; however, it does predict a higher chance of dropping out.

Does age matter?

- The two largest courses (SOLAR and WATER) showed a very significant age difference between completers and non-completers, and a significant correlation between age and grade.
- Age seems to be correlated with higher performance (and 'completion') as well as early dropout (hence: 'non-completion'). Older students tend to drop out without doing any graded assignments, while if they are serious about the course, they perform better than younger students.
- It seems that most students can be categorized as adult learners ensuing pedagogical implications for course design.

Pedagogy or Andragogy?

- Pedagogical decisions around the first generation of DelftX MOOCs are diverse and not a single MOOC is the same.
- This is also true for the degree of control exercised by teachers, and the degree of autonomy of the students.
- The structure and positioning of the edX forum varies with more or less integration in the learning activities and content.

- Also the provision of individualized feedback differed from 'laissez faire' to more individual feedback strategies.
- The assessment strategies ranged from highly controlled with a strong emphasis on structured examinations to a more open approach with the emphasis on homework, open ended questions and peer assessment.
- The design strategy needs to consider the characteristics of the adult learner (andragogy) and ensuing pedagogical implications.

Social aspects of learning

- Cultural preferences for social learning has been found to differ: English speaking students, students of Germanic culture, and Eastern Europe tend to prefer to work alone, while students from South East Asia, Middle East and African cultures prefer to work together with others.
- Students use the forum mostly to discuss confusions or solutions related to tasks.
- Students who intend to receive a formal certification are more likely to engage in class discussions.

The students view on the MOOC is biased, because the majority of the respondents on the end-survey were completers. Nevertheless it is interesting to grasp their reaction. They felt quite confident in handling the course. In their opinion there is certainly something to gain when it comes to social interaction. The participation was low and a majority indicated that they would have liked to connect with other students more than they did. In general the students felt rather well in the course and had a feeling of belonging. Important was that a majority found that their expectations about the course were realistic and that they would like to do another course with the same teacher.

For the other stakeholders and predominantly the teachers and developers the reason 'to mooc' was to expose themselves to the world as experts with a clear notion to improve their education, not only online, but also on campus. Time pressure was mentioned as a main issue due to uncertainties in the coordination, production time, agenda and other organizational practices. The MOOC has generated lots of attention and enthusiasm for education and is experienced as a change maker for the good of education in general.

7.1. Future direction

The MOOC has changed the playing field in education and online learning in general has gained attention and appreciation never seen before. It is still unclear how this story will evolve, but it is evident that at the TU Delft the MOOCs have initiated a discussion and raised the awareness of teachers of the value of learning innovation and as such created a momentum for further development.

There are a few issues discussed in this report that deserve further attention:

- The Educational Data Mining (EDM) / Learning analytics as applied can be improved, not only to serve researchers, but also to assist the teaching staff in their daily working practice and their strive to improve learning design.
- It is a challenging issue to learn from the data and experiences and use these to improve education. For this to happen an holistic approach is needed, because one thing MOOCs have shown is the need for a balanced interrelation of all elements within the 'Educational Business Column' (management, administration, content, course design, technology) to produce and deploy high quality open and online education.
- Insights from one MOOC are often not repeated in other MOOCs. Findings have to be seen primarily in the context of a particular MOOC, rather than a generalizable outcome, even though the number of respondents is great. Also, datasets that comprise data from various MOOCs should be analyzed carefully.
- The consequence of the variety is that lots of MOOCs need to be analyzed, domain or not domain specific, to develop guidance for the improvement of course design and relatively new issues as student participation, engagement, and others.
- This implies that the research needs to favor openness for data exchange and collaboration with other institutions and groups. A framework for open research has been developed and applied during the past period, but this needs to be extended and formalized to make it future proof.
- It is feasible to say that online education is considered critical to the long-term strategy of Higher Education (HE) with consequences for the current professional development policy. The problems faced during the development and deployment of a MOOC originates partly from the point that educators teach and develop online courses with little or no prior training. An improved professional development strategy is needed to facilitate and support faculty in a timely manner with a focus on learner-centered development to comprise the diversity in needs.

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