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Dropout rates of regular courses and MOOCs

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Abstract: Recently we observe an enormous grow of Massive Open Online Courses (MOOCs). But it proves that the dropout rates of MOOCs are very high. One of the main causes are missing of necessary capabilities of students, inability of students to manage their study and a missing appropriate didactic model. In this paper we compare the dropout rates of MOOCs, regular courses and courses using new didactical approaches as blended learning and flip the classroom. Finally we discuss possible ways how to teach 21st century skills as cooperative working, learning, creativity, networking and how to solve real life problems in a context sensitive approach. Our research findings are based on educational experiments at Delft University of Technology (DUT).

1 INTRODUCTION

In a complex, globalising, unpredictable world full of networks, worldwide communications and social media we have to train students in acquisition of typical 21st century skills such as critical reflection, cooperating, networking, creativity, ability to handle big data, ability to solve real life problems, ability for life-long learning. We have to educate students which are able to face and contribute to the future world (Bussemaker, 2015). The question is whether and how educational innovations as “blended learning” and MOOCs enable students to acquire such skills. It is not enough to offer courses as MOOCs but it is also necessary to develop didactic models to challenge students to take this courses and complete them successfully (Rothkrantz 2015).

The process of teaching and learning has an impact in three domains (Bussemaker, 2015):

- Qualification, this is about the role of teaching in acquisition of knowledge, abilities, competencies, and attitudes such that after graduation students are qualified to perform their job or play their role in society.
- Socialisation, this is the way how we teach students the social processes in a job environments or culture and democracy in general.
- Personal development, the impact of teaching on the process of individualisation and subjectivity.

The question is how to realise these goals with a student population of increasing diversity, differences in cultural background, interest, abilities, learning style, speed/pacing. Most regular courses are focussed on realisation of the qualification goal. By introducing MOOCs and blended learning courses the hope was that they support socialisation and personal development. But as we will show in common used didactic models it is assumed that students master already 21st century skills. But in most secondary schools these skills have not been trained, so they have to be learned at University. From a recent study in the Netherlands (Bussemaker, 2015) it proves that the teaching process at Universities is still focussed on knowledge transfer and qualifications of students and not on socialisation and personal development. The concept Bildung introduced by Humboldt in the 19th century focussed on the development of all human abilities and not only some cognitive abilities and knowledge acquisition is a relevant item.

To realise such educational goals there is a request of smaller learning communities with intense interaction students and teacher. But in MOOCs the direct interaction with a teacher is minimised and is embedded in the teaching material in a non-direct way. We observe also a trend of creating honours programmes challenging and enabling students to compose their individual self-paced programmes. Concepts as freedom, responsibility, societal relevance and innovation, are very appealing to students. But we can observe that only a minority is able to implement such programmes successfully.

Many students don't know what they really want, are not aware of requirements of individual studies and of the required capabilities. MOOCs have a high dropout rate because students don't have the required capabilities, attitudes and ability to control their own study behaviour. Student are used to take precooked programmes and a teacher taking the supervision on their study. Self-paced studies require a new study behaviour which has to be learned.

In section 4 we discuss the results of a psychological assessment at TUDelft. First years students were tested using the Big Five personality test to assess if students have the abilities to learn 21st century skills (Rothkrantz, 2015). Then we will discuss the results of a huge experiment performed at TUDelft from 1953-1957 (Bottema 1959). Students were tested using personality tests, (cognitive) ability tests, completed with interviews of student counsellors and surveys on assessment of features in the teaching-learning environment. The goal of this experiment was to research if psychological assessment could provide additional information next to the results of final examination at secondary schools to predict study-success or –failure. In 2014 an experiment has been started using new teaching learning models in mathematical courses for first years students at TUDelft. Again we will report the study performance of students compared to traditional ways of teaching mathematics. To summarize the goals of this paper are:

- Identification of factors/reasons explaining the high dropout rate of MOOCs.
- Comparison of factors underlying different teaching-learning models varying from classroom teaching up to MOOCs, with respect to study -success or –failure.

Our research findings are based on results of experiments performed at Delft University of Technology.

2 LITERATURE SURVEY

In (Onah, D.F., Sinclair, J., Boyatt, R., 2014) the authors researched MOOC drop rates from different perspectives. They listed a number of reasons for dropout based on literature search. Next they researched data from a specific MOOC provided by the University of Warwick. Their results indicate that many participants who may be classified as dropouts are still participating in the course in their own preferred way, either with a slower pace or with selective engagement .

In (Yang, 2013) the author explores students dropout behaviour in MOOCs. As a case study they took a special class. He developed a survival model that allows to measure the influence of factors extracted from that data on student dropout rate. His study shows that specific social factors as interaction between students, emergent sub community structure affect dropout behaviour

In (Tanmay Sinha, 2014) the author researched the underlying interaction mechanisms which govern students' influence on each other in Massive Open Online Courses (MOOCs. Specifically, they outlined different ways in which students can be negatively exposed to their peers on MOOC forums and discuss a simple formulation of learning network diffusion, which formalizes the essence of how such an influence spreads and can potentially lead to student attrition over time.

In (Cheng Ye, Gautam Biswas, 2014) the researchers extended traditional features for MOOC analysis with richer and higher granularity information to make more accurate predictions of dropout and performance. The results show that finer-grained temporal information increases the predictive power in the early phases of the Pattern-Oriented Software Architectures (POSA) tested on a MOOC offered in summer 2013 by Vanderbilt University.

Prediction of study success is a popular research topic over the years. (Wilbrink, 1997) shows a literature survey of assessment in historical perspective with more than 200 reviewed papers.

In (Tinto,1975) ia theoretical longitudinal model has been introduced, demonstrating how different personality characteristics and characteristics of the University have their impact on the interaction process student-University. Such a process resulted in delay, dropout or study success. In fact Tinto describes the interaction process between three systems, the individual student, the academic system and the social system. According to Tinto the individual student will enter the University with a specific social background, personality education and training. He will have a special binding with the University and goal of the study. This binding will be expressed in motivation and expectations. The binding will change over time, caused by the influence of the academic and social systems and the interaction of both and will eventually result in dropout.

A similar study has been performed in Belgium at the Universities of Ghent and Leuven. Researcher Lacante and Janssen were involved in research on prediction of study-success for a long time (Lacante, 1981). They developed special surveys to predict the academic performance at Universities. They found similar results as the researchers at Delft University with some refinements.

The didactic Adagio of the famous Dutch mathematician and didactic specialist in mathematics Freudenthal (Freudenthal, 1973) was "You can learn mathematics only by doing and discover mathematics in the real world". For him was teaching mathematics an educational task and it should be context sensitive and application oriented. Students should be able to design mathematical models and translate real world problems formulated in natural language in a mathematical language. It is very important to give students opportunities to reflect on and clarify their thinking about mathematical ideas. Most of current didactic models fits in the discovery learning tradition developed around 1960. Piaget, Dewey, Vygotsky and Freire and many others support constructivist learning. Up to then drill and practice was one of the favourite pedagogical principles in mathematics. Now the focus is on learning based on personal and societal experience. Our developed didactic model FETCH 2.0 is based on similar ideas (Rothkrantz, 2015). The question is of course how to implement this didactic model in the developed MOOC. The oldest, and still the most powerful, teaching tactic for fostering critical thinking is Socratic teaching. In Socratic teaching we focus on giving students questions, not answers. The next step is that students themselves learn to generate questions around a learning text (Rothkrantz, 2015).

Mathematicians are trained to ask (critical) questions reading a scientific journal. These questions are stimulated by the learning material but also by the surrounding environment and context. Developing a critical attitude by students is not limited to mathematics. Freudenthal writes about "Mathematics as an educational task". Many mathematicians use the inquiry based methods also during reading or reviewing a paper, or documents or listening to a presentation. It proves that inquiry based method is an efficient way to keep the reader/listener alert and is a first step to processing the presented information.

3 REASONS FOR DROPOUT

In this section we discuss possible causalities of the high drop off rate of MOOCs. TUD launched 20 MOOCs, accessible via edX platform. In this section we focus on the MOOC Pre-Un Calculus, visited by more than 26.000 students. Via interviews and questionnaires experiences of students and teachers are assessed and reported in (Vos, 2015). Most (early) dropouts from the course didn't take part in the assessment procedure, so we realise that the results are biased.

MOOCs are in principle open for everybody. No entrance exam has been required. But some knowledge and capabilities are required to finish a MOOC successfully. This is stressed in information about the course but some students still believe they can do it. Similar experiences we have with regular students at DUT. No entrance exam is required to enter TUD. The first year of study should be used for selection, orientation and adaptation. It proves that low grades for mathematics and physics at secondary school are good predictors for dropout. Over the years the failure rate of regular academic courses has been studied. We will report about a study at Delft University of Technology with a psychological assessment of all freshmen. It proves that results of students at their secondary school predict about 40% of the study success or failure in the first year. Psychological assessments ads about 10%.

To complete a MOOC successfully a student should have a strong motivation, based on the expected outcomes, interest in science and increase of knowledge and competences. Next a student should be able to manage his time and plan a study. In the current MOOC a global time schedule of video lectures, simulations, exercises and exams is presented. To enable communication and cooperation between students all students are part of one group taking the course together. In more individual based schedule students will lack support of fellow students. Many students reported that they prefer to manage their own course without cooperation. This violates of course the goal to realise 21st century skills. Individually based studies are offered for many years by the open University. But they also offer meetings for participants to create a community. Given a strong motivation and ability to plan their study, students should be able to come to activities. Viewing video lectures and simulations don't require active participation of students. It may give them the feeling that they have everything under control. They are confronted with reality if they have to make assignments or exams. Inadequate time management, un-ability to set themselves into action and missing of other study skills, results in many cases to dropout.

An adapted didactic model for MOOCs is needed. Recorded web lectures of gifted teachers or successful lectures are no guarantee of high study success of MOOCs. In many cases the didactic model of regular courses in lecture halls is copied. A teacher explains the theory, gives some examples during the course and students are supposed to study the learning material and to make exercises. But making homework is a great problem. The gap between lectures and making exercises is (too) big and most students are not able to manage their time and set themselves into action.

It can be observed at TUDelft that a week before the exams students start to visit libraries, study-halls etc. to start their preparation for exams. Observing this study behaviour of fellow students triggers other students to start similar behaviour. It is difficult to implement similar triggers in the MOOC community. But we have to realise that used didactic models assuming regular study behaviour of students in general don't work for MOOCs. In regular students are creative in finding alternatives observing peer models what is still missing in the MOOC community.

Personal, intensive study guidance results in better study results. A good binding with the study and study community is an essential prerequisite for successful study. Unfortunately the massive character of MOOCs makes individual tutoring by teachers impossible. One of the assumptions of creating a study community via social media is that students will support each other. But it proves that creating study communities is far from trivial. One of the outcomes of the surveys is that many students don't like networking and cooperation and prefer to study in their own individual way. Students get stronger involvement with the study and study community.

To be a member of a learning community has a great impact on the motivation, emotions and study results/achievement. (Furrer and Skinner, 2003). It is important to give students the feeling that it is exceptional to take these courses and that they should be involved in learning communities. In case of MOOCs it cannot be expected that there is much individual support or supervision of teachers. Fellow students can take the role of a teacher and the community of fellow students should support and stimulate the members of the community.

Many students following MOOCs don't live in a student environment. Via social media they can be involved in learning environments. Participation in such an environment is important to develop 21st century abilities. MOOCs offer the opportunity for internationalisation, integration of research in the learning environment. In research based education students are involved in common research activities and in research tutored education students perform research activities themselves.

Students following MOOCs have to take the responsibility for their own learning process. It is definitely true that part of the students are able to manage their study. But most students need group pressure, supervision of teachers, counsellors, fellow students to complete a MOOC successfully. Nevertheless many educators prefer self-paced instruction so that every student is able to define his individual study path. This enables students to accomplish their study at their own speed. But it creates problems to give support from the community. In the Netherlands some PhD students have to follow MOOCs instead of common courses at some University. This is highly appreciated by PhD students and the success rate is high. After completion of a course PhD students are supposed to do an exam at the home University.

4 EXPERIMENTS

4.1 Big Five personality Test

One of the research goals of this paper was to investigate how to teach students 21st century skills as networking, cooperation, creativity etc. Traditionally teaching mathematics is rather individually oriented. A lecturer introduces students in lecture halls into new topics. Students listen and make notes. Parallel to the lectures are usually lab hours during which time students are supposed to make exercises alone or together. Especially during the lectures students are passive consuming knowledge, instead of exploring new topics and discover new knowledge and even more important it is an individual process. It takes students less energy to listen to lecturers and see how he discovers new knowledge. But the challenge is to take students out of their comfort zone and challenge them to actively search for knowledge and problem solving.

Changing the didactic approach may change the learning attitude of students. It can be expected that there will be resistance leaving the comfort zone. A second question is if students have the right personality characteristics to learn the 21st abilities. If students are not able to cooperate, socialise and network there is a problem. To research that problem a group of first years students in mathematics and computer science were tested using the Big Five Personality test in September at start of the academic year. Students were supposed to fill in a questionnaire of 4x5 questions. Then the score on 5 factors E, A, C, N, O listed below were computed. Students with high scores on the factors A and O are supposed to be open for learning the 21st century skills. But it proves that students score significant lower on A and higher on O. This supports the hypothesis that students in technology or exact courses have the tendency to work individually and are open for new knowledge. The factors underlying the Big Five Personality test can be described as follows:

Extroversion (E) is the personality trait of seeking fulfilment from sources outside the self or in community. High scorers tend to be very social while low scorers prefer to work on their projects alone.

Agreeableness (A) reflects much individuals adjust their behaviour to suit others. High scorers are typically polite and like people. Low scorers tend to 'tell it like it is'.

Conscientiousness (C) is the personality trait of being honest and hardworking. High scorers tend to follow rules and prefer clean homes. Low scorers may be messy and cheat others.

Neuroticism (N) is the personality trait of being emotional.

Openness to Experience (O) is the personality trait of seeking new experience and intellectual pursuits. High scores may day dream a lot. Low scorers may be very down to earth.

Table 1: Average values of the five factors of the Big Five test E, A, C, N, O for a cohort of TUD students computer science and mathematics and a general cohort

Number of respondents	10189	179
Extroversion	3.05	3.05
Agreeableness	3.84	3.69
Conscientiousness	3.38	3.06
Neuroticism	2.98	3.39
Openness	4.05	3.71

From Table 1 it can be observed students mathematics and computerscience have the same average score on the factor Extroversions indicating that in principle they are open/not open for social contacts and open/not open for networking.

The students in the TUD cohort score lower on the factor Openness and less open for new experience and intellectual pursuits. But we may conclude that students in exact/technical sciences are in principle open for learning 21st century skills.

4.2 Psychological assessment procedure at TUDelft 1953-1957

For most academic studies at Universities in the Netherlands there is no entrance exam. Only a limited studies with capacity problems have a special admission procedure. Students with low grades at the final exam at their secondary school have a lesser chance to pass this special entrance procedure than students with higher grades. As a consequence many students start a study with insufficient intellectual capabilities. The assumption is that Universities have the opportunities to select the students for the higher years based on their academic performance in the first year. It is a well-known saying that students with limited intellectual capabilities can compensate this shortage by hard working. To research the impact of personality characteristics, motivation, social environment on academic performance and study-success or –failure a huge assessment procedure was performed in 1953 at Delft University of Technology. All students in the first, second and third year got a psychological assessment. They were supposed to fill in questionnaires corresponding with test assessing cognitive abilities, and personality. Next all students were interviewed by student counsellors. The outcomes of all these assessments were correlated with the results of exams of students and results of students at their secondary school. It proves that there was a significant correlation between academic performance at the University and final results at secondary school for the subjects mathematics and physics. Not a big surprise taking into account that the subjects mathematics and physics play an important role in technical studies at Delft University of Technology. From table 2 we can see that students with lower grades for the subjects mathematics and physics have a low study progress in the first year and students with high grades have a high chance of study success. For the middle group of about 50 % it was difficult to predict study success or –failure. A disappointing result was the fact that the outcome of psychological assessment has a very limited added value to the prediction of study-success or –failure. Apparently the impact of personality, social environment were already included in the performance at secondary school.

Table 2: Study-progress/delay/dropouts in percentages crossed with average score mathematics/physics grades at school, after two years of study, cohort 1953

Studyprogress ≥ 150%	0%	4%	11%	15%	7%
Studyprogress ≤ 150%	0%	8%	13%	4%	0%
Delayed students with Incomplete first year	2%	2%	1%	1%	0%
Dropouts during second year	2%	6%	2%	0%	0%
Dropouts during first year	2%	9%	9%	1%	0%
Average math/ physics grades at school exam	5-6	6-7	7-8	8-9	9-10

Table 3 Study-progress/delay/dropouts crossed with number of passed exams in the first exam-session

Studyprogress ≥ 150%	0%	1%	7%	14%	16 %
Studyprogress ≤ 150%	3%	8%	8%	4%	3%
Delayed students with Incomplete first year	2%	1%	1%	0%	0%
Dropouts during second year	2%	6%	1%	1%	0%
Dropouts during first year	6%	9%	5%	0%	0%
Numbers of exams passed successfully in first period	0	1	2	3	4

From table 2 can be observed that the dropout rate in the first two years is 31%. After two years of study the dropout rate was 31%. In total the dropout rate was 43%. About half of the dropouts started another study at TUD or at a Polytechnique School. The function of the first year was orientation and selection. But still 10% of the students started a second year and dropout during that year and additionally 12% of the students drop out later in the study. At this moment the University spend a lot of time and effort to stimulate students to take their decision of dropout as soon as possible. At this moment it is in general not possible to start the second year before completing the first year. There are special programs and even a special MOOC enabling student to get a better orientation of the study.

A special problem with presented tables is that some students enrolled in the study but never show up. In the early days even no-show students could get a student loan for the whole year. So no-show behaviour has financial consequences. A similar problem can be observed in the cohort of MOOCs students. In the past the group of slow starters made a successful start in the second year. The phenomena of restarting students is not observed in the cohort of MOOCs students. One of our recommendations for MOOCs designers is to take care of slow starters, students who need a longer adaptation time or to apply the spiral principle of in increasing difficulties.

Students with a low respectively high average score on the subjects mathematics/physics have a low chance/high chance to complete the study successfully. But students with modal scores are rather unpredictable. The hope was that psychological personal improved prediction of study-success or failure for the middle group. Unfortunately this was not the case.

From Table 3 can be observed that dropouts miss more than half of the exams already in the first session. Some students with bad results in the first year give themselves second start but have again bad results in the first exam session. The phenomena of restarting students is not observed at MOOCs.

4.3 Pre-University calculus July-September 2015

TUDelft designed a special MOOC called Pre University calculus. The goal of the MOOC was to refresh mathematical knowledge of students before they start their academic study at the University and to teach students missing topics of the mathematics at secondary schools. The teaching material was composed of small, 10 minutes video fragment with a lot of simulations, video lectures, gaming etc. The focus was on applications of mathematics.

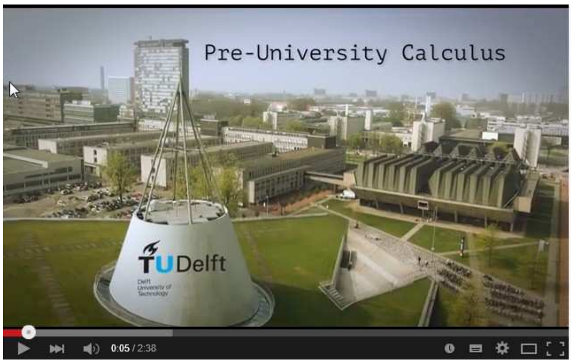

Figure 1: Screenshot of the Pre-Un. Calculus MOOC

Students were stimulated to cooperate by interacting via special blogs. Students are stimulated to define questions stimulated by the lectures and the learning material. Fellow students in the network are invited to answer the questions and commenting solutions in the course forum. This is common practice in mathematics learning.

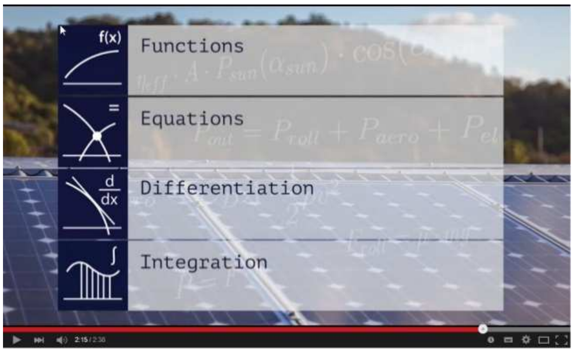

Figure 2:Topics of the Pre-Un. Calculus MOOC

In 2015 more than 26.000 worldwide followed the course and via data analytics the performance of students was analysed. We will report some main findings from participating students, first students from TUD and after that students from all over the world. Aspirant students from TUD were stimulated to take part in the special MOOC. Usually lectures were offered during the summer holidays after the school exam and just before the start of the academic year. The MOOC was supposed to attract more students because there was no need to come to the University and also no need for teachers to lecture to lecture during the summer holidays.

In total 794 TUD students enrolled in the course, 420 (53%) of them attempted an exercise and 40 (5%) attempted all exercises. Only 46 students passed the final exam successfully. From the interviews it proves that most students had the feeling that they master the topics already. Just before the start of the academic year, other activities got a high priority as finding housing in Delft, increasing the income by performing a job or just taking holidays after passing the school exam successfully. Students didn't feel the need to participate in the MOOC.

From table 4 it can be observed or computed that there is no significant difference in mathematics grades between students that enrolled and students that did not enrol.

In total 27.186 students enrolled in the course, 4.150 students attempted to make an exercise and only 273 attempted all exercises.

Table 4: Distribution of students who enrolled and didn't enrol in the MOOC

	Grade math at school exam					
	5	6	7	8	9	10
# of students that did not enrol	101	764	1017	703	332	52
Number of students that enrolled	32	173	200	166	63	10

All students were requested to fill out some questionnaires. We report the results from students who showed some activity in the course. About 59 % of the students took part in the course from begin to the end, 18 % browsed through the topics and videos and 4% mainly watched the videos, 7% mainly did the exercises.

Students on average stated they rarely participated in study groups, connected to other students, posted a comment or a question, or looked at the forum. They also rated their perceived support from either other students or staff rather low.

However, they did not feel that feelings of loneliness or missing interaction negatively affected them in the course. Neither did they feel that lack of feedback negatively affected them. Rather, they rated the feedback as good. It seems, students in general neither expect nor need a lot of interaction with either students or staff. We stress that this only holds for students taking part in the course. From students who didn't take part or dropout in an early stage we have no information.

4.4 Experiment Mathematics at TUD during 2015

It was decided that teaching mathematics at TUDelft will change dramatically from 2015 on.

The dropout rate had to be reduced. There should be more focus on applications of mathematics, self-discovery, teaching 21st century skills such as networking, cooperation via social media etc. In a first experiment 370 students studying Civil Engineering got mathematical courses new style. First the didactical principle flip the class room was applied. For many years students got their lectures mathematics in big lecture halls followed by making exercises in small classrooms. Now the order has been changed. Students are supposed to study video lectures and make exercises before they meet the teachers and fellow students in small classrooms to discuss problems and outcomes of the exercises. In the video lectures there was a focus on applications of mathematics, self-discovery activities of students. They are stimulated to cooperate in study groups. The MOOC Pre-Un Calculus was integrated in video lectures. Many new videos were added especially on simulation and applications of mathematics.

We will now report some of the results from surveys and interviews. It proves that on average only 20% of the students viewed the video lectures before the classroom meeting. So the assumption that students activate the right pre-knowledge was not correct. That poses a didactical problem for the teacher. Repeating or summarising the homework is boring for students making their homework and will not stimulate viewing video lectures in the future. One of the critical comments of students was that the video lectures are interesting but are not direct integrated with the learning material/book. Viewing the video lectures maybe will result in a better understanding of mathematics in general but it is not necessary to pass the exam successfully. One of the goals of the new mathematics teaching was to focus on real applications. Then the applications should be part of the exam and not additional. In the compulsory homework assignments it is possible to make links with some topics discussed in the video lectures.

At start about 80% of the students visited the classroom meeting and at the end it was about 65%. The classroom meetings were highly appreciated. Especially the moments the teacher was lecturing or explaining difficult topics. It proves that teachers were better in raising questions or pointing to typical problems. Individual or group wise making assignments during the classroom lectures was highly appreciated. Because there was a meeting place for the students in the classroom there was no need to cooperate via social media. Teachers were asked if and how many times during a lecture they provide opportunities for students to discuss topics or cooperate. In the next table we summarise the results.

Table 5: Overview of opportunities teachers offered for discussion or cooperation.

Opportunities for discussion or cooperation	Never	1 time	2-3 times	4 or more times
	11%	22%	34%	33%

Teachers like to teach and play a central role during the lessons. Many students come to the lessons and expect that the teacher lectures. Parallel to the classroom meetings there was a digital Lab room (My.MathLab). Students were supposed to make assignments and got feedback in an automated way. It proves that many students joined their effort and meet each other to make assignments

An interesting option for students was to provide feedback during the lectures using their smart phones or laptop. One of the start up companies from DUT, FeedBackFruits developed a tool for mobile devices which enables students to ask questions during a lecture. The questions are visualised on a display in front of the teacher. It proves that students consider the tool as an interesting option. But defining questions takes some time and usual the lecture is going on. It is up to the teacher if he introduces breaks to allow and discuss questions. Some questions can be used by the teacher to summarize a topic. If there are many questions about the same topic the teacher has the option to explain the topic in an different way or to come up with some examples. To support the didactical approach “flip the classroom”, the start up company FeedBackFruits was requested to generate a plugin to make the “questioning tool” available via edX, one of the MOOCs consortia. A layer of new functionalities was developed over the edX platform. This enables students to make specific notes inline and make digital notes out of it. The plug-in also allows users to add new content to the course and share a message information board way questions of the students can be considered as an online feedback system for the teacher.

5 CONCLUSIONS

The main goals of this paper was to study the high drop off of MOOCs, to find possible causes and to develop a new didactical model. Secondly we want to invest in how far if it is possible to teach students 21st century skills. We used the data from two experiments at TUDelft.

In the first experiment, TUDelft designed a special MOOC called Pre University Calculus. The goal of the MOOC was to refresh mathematical knowledge of students before they start their academic study and to teach students missing topics of the mathematics teached at secondary schools. The teaching material was composed of small, 10 minutes video fragment with a lot of simulations, video lectures, gaming etc. The focus was on applications of mathematics. Students were stimulated to cooperate by interacting via special blogs. In 2015 more than 26.000 worldwide followed the course and via data analytics the performance of students was analysed. Only a minority of 5% of the students completed the course successfully. These students stated in surveys and interviews that they prefer to work individually and not in groups or digital community. Unfortunately the early dropouts were not surveyed. From the questionnaires and interviews we found many reasons for dropout behaviour. From the available data can be concluded that there were only a few network activities and cooperation between students via social media. Teaching students 21^{st} century skills will not take place automatically by using MOOCs but special didactic models are needed.

Secondly it was decided that teaching mathematics at TUDelft will change dramatically from 2015 on. There should be more focus on applications of mathematics, self-discovery, teaching 21st century skills such as networking, cooperation via social media etc. In a first experiment students studying Civil Engineering got mathematical courses new style. First the didactical principle flip the class room was applied. For many years students got their math lectures in big lecture rooms followed by making exercises in small classrooms. Now the order has been changed. Students are supposed to study video lectures and make exercises before they meet the teachers and fellow students in small classrooms to discuss problems and outcomes of the exercises. In the video lectures there was a focus on applications of mathematics, self-discovery activities of students. They are stimulated to cooperate in study groups. It proves that less than 20% prepared the lessons by viewing the video lectures in advance. Most students reported that lack of time and motivation was the main reason. And they expect that the teacher will summarise the main topics in the lessons so that they are able to follow the lessons. Following the lessons is important for the students because they expect the teacher will provide essential information needed to pass the exam successfully. Students cooperated via the digital Lab making homework together. In the lessons there was less cooperation also because the teachers didn't provide the opportunity. During the lessons and video lectures students were able to give comment or asking questions. This provides essential feedback for the teacher and information for the evaluation of the course. Again we to conclude that blended courses don't guarantee that students learn 21^{st} century skills.

Students mathematics and computer science got a psychological assessment using the Big Five personality test. From the results it proves that students have the abilities to learn the 21^{st} century skills but this will not happen automatically. A special didactic model is needed.

A comparison was made between a huge assessment study at TUDelft during 1953-1957 and recent experiments at TUDelft. It proves that over the years 40% of the students dropout. We reported many causes based on surveying and interviewing students.

As a final conclusion we state that also regular courses have high dropout rates varying around 40%. Many attempts to reduce the high dropout rate were not successful over the years. MOOCs show even higher dropout rates and we conclude from the outcomes of surveys and interviews that lack of cooperation in networking, lack of social control of peer students and inability to manage the study were the main causes of high dropout rates.

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