

Preliminary analyses showing the positive impact on student performance by the implementation of flipped classroom concept in the on-campus course ET3034TU 'Solar Energy' using the DelftX/edX MOOC.

Arno Smets, December 8th 2014, TUDelft.

Abstract: In this report, the first results on the implementation of the flipped classroom concept in the on-campus course ET3034 'Solar Energy' 2014 show an increased efficiency of the performance of the students. The on-campus students spend their time more efficiently, are able to study and master more material and accomplish better grades. Overall higher passing rates are achieved in reference to teaching in classical classroom approach over the period 2010-2013. The majority of the students express that they prefer the flipped classroom approach above conventional teaching methods.

Experimental details

In the first quarter of the academic year 2014-2015, the flipped classroom model was introduced in the on-campus **course ET3034TU** using the DelftX Solar Energy MOOC developed for the edX platform. The 2nd edition of the MOOC (September 1st 2014) started simultaneously with the on-campus course. The students were expected to follow the lectures online as homework: in the first week, the lectures of week 1, in the second week the lectures of week 2, etc, etc... In week 7 they had to do the MOOC lectures of week 7 and week 8. I was able to teach the entire content of the MOOC in the on-campus course. It is noteworthy to mention that this means that I was able to cover **~30% more material** than I used to do in the classical classroom concept! This has made my teaching far more effective. In the lecture room (face-to-face contact hours with students) I have focussed on solving problems such as exercises on the level of the exams, content experienced by the students as difficult and other additional requests of the students. Below the results of the written exams and the results of a questionnaire offered to the students during the exam are shown. Finally, a small reflection from my side as lecturer and some feedback comments from students are presented as well.

Exam Results

62 on-campus students participated in the written exam in the evening (18:30-21:30) of October 29th. The challenge for monitoring improvements is to define the reference group. The reference group represents students that participated in the 'classical classroom' approach. Here, the results of 214 students that have participated in the exams of 2010, 2011, 2012 and 2013 are taken as the reference data. The level and structure of the exams from 2010 up to 2014 are the same (including the corrector of the exams = me). Be aware that it does not fully exclude the possible effect of extreme year-to-year fluctuations. Nevertheless, the passing rates in the period 2010-2013 were rather reproducible and fluctuated between 67% and 72% (See figure 1). As shown in

figure 1, the **passing rates** went up from averaged **71%** in the period 2010-2013 up to **89%** in 2014.

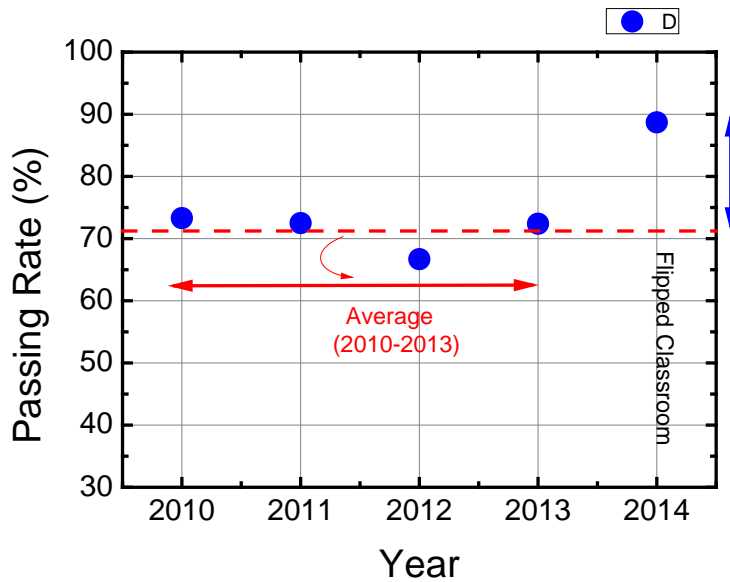


Figure 1

As shown in figure 2, the **average grade** of **6.51** (on a scale from 1 to 10) for the period 2010-2013 went up to **7.09** in 2014, showing an increase of **0.58**. Note, that this is smaller than the typical standard deviation of the broad distribution in grades, but still significant, as shown by the distribution in Figure 3.

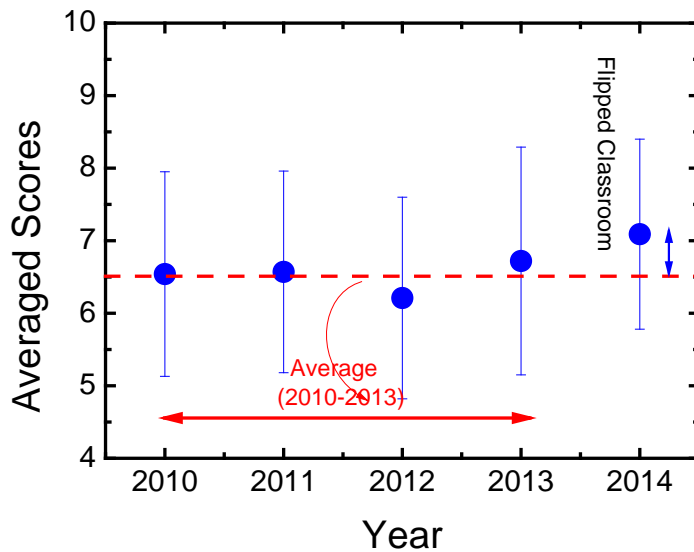


Figure 2

The normalized grade distribution in figure 3 shows that the flipped classroom concept mainly affects the group students that are in the *grey area* around the critical pass-fail zone, i.e. scores between 4 to 6. This explains why the positive effect of the flipped classroom is more evident in the passing rates than for the averaged grade.

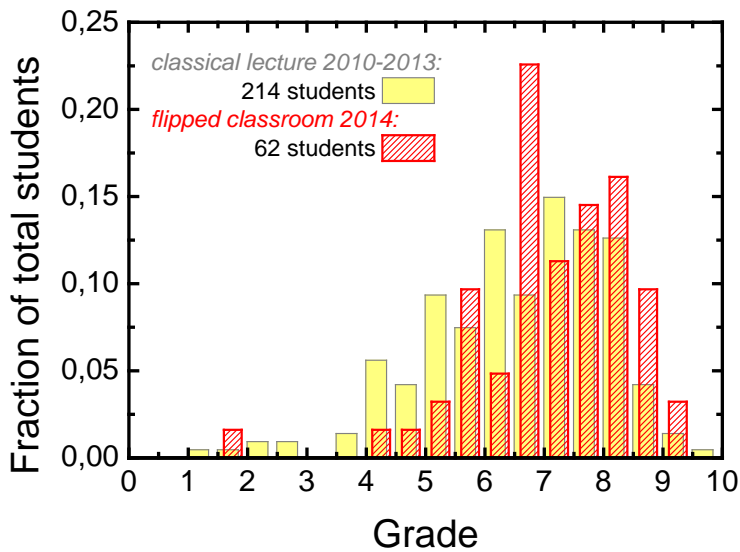
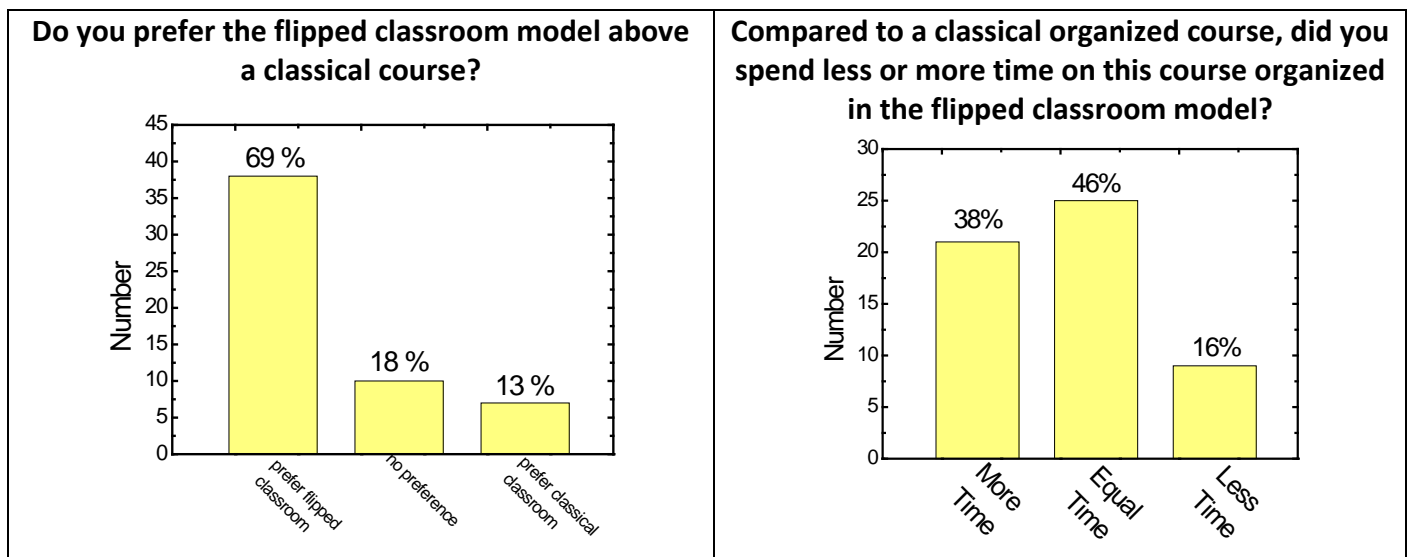


Figure 3

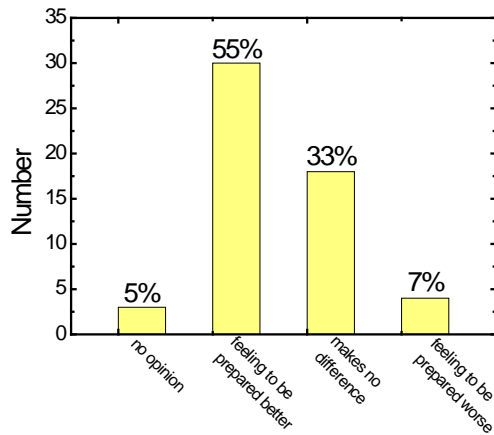
Questionnaire

55 out of 62 students have filled in a questionnaire directly after the written exam. Most important observation is that **69%** of the students **prefers the flipped classroom approach** above the classical teaching approach. Only **13%** prefers the **classical classroom approach**. Strange enough the students in favour of the classical approach attended on average only 3 lectures offered on-campus???. In general, the students indicate that they think they have spent slightly more time on course because it is a flipped classroom course instead of a 'classical classroom' course. In addition, the results demonstrate that the students spend their time more efficiently. With respect to attendance in the on-campus lectures: **53%** of the students joined **5 or more lectures**. Note, that **25%** of the students joined **not more than 2 lectures** and therefore heavily and solely depended on the online material offered.

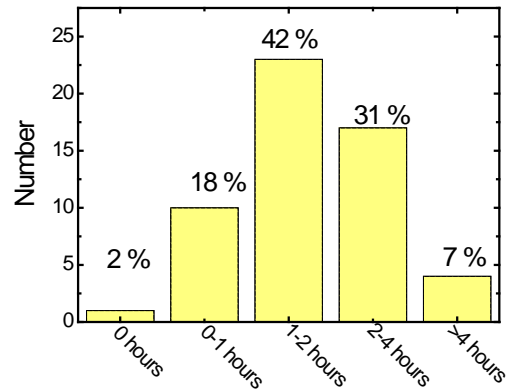
The students' responses to the questionnaire are shown below in the Table:



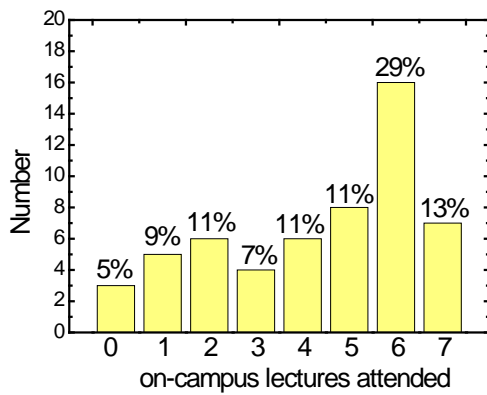
Do you think you were better prepared for today's exam due to the flipped classroom model?



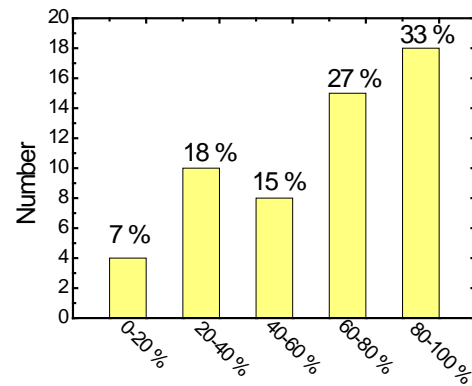
How many hours on average per week did you spend on watching the video lectures on edX platform?



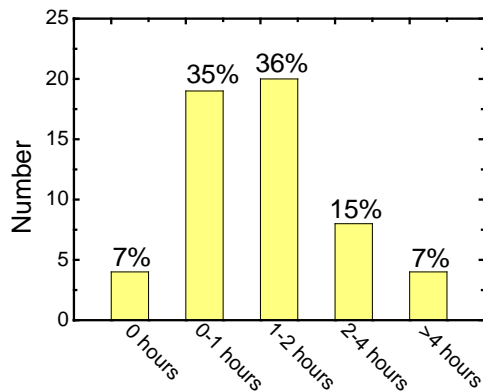
How many on-campus lectures on Wednesday morning did you attend?



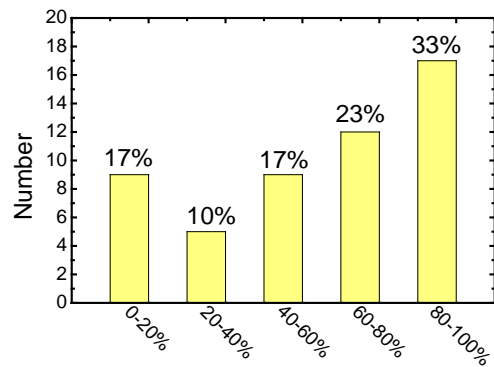
What fraction of the exercises, assignments and exams offered on the edX platform have you used as practice material?



How many hours on average per week did you spend on this course excluding video lectures and on campus lectures?



Did you watch all video lectures as requested before attending the Wednesday morning lectures?



Review of the lecturer/ impact on the lecturer.

Teaching in the flipped classroom model is far more relaxed than teaching in the classical approach. In the classical approach, you are always in hurry to guarantee that you have covered all material scheduled for that specific lecture. This time pressure is completely absent during the flipped classroom approach. In the lectures, I work with the students on exercises. I have selected exercises that focus on the most important content in the course or focus on content considered to be rather difficult by the students. My impression was that at the end of the course, the level of understanding of large group of students, was much better than in the earlier editions of this on-line campus course. Students feedback in the classroom was positive.

Potential further improvements could be realized, when the presence of the on-campus lectures is made compulsory. But this might be one bridge to far, as a practical problem this fall was, that a few students had a course scheduled at a conflicting time.

Additional comments of students on the questionnaire:

Below, 17 additional comments given by the students on the questionnaire are given. Most comments are not directly related to the flipped classroom model. Where needed, I included a response from my side.

A "Fun class. I appreciated your enthusiasm and passion of the subject"

B "It might have been better if the video lectures were only for the TUDelft students and different lectures for the MOOC courses."- *response Arno: This student favours the classical approach. I don't understand his viewpoint though.*

C "Learned a lot!"

D "The course had more material to study and always possible to go back to a particular part of a particular lecture. All course shall be organized like this. Only downside is the lack of feedback on blackboard". *response Arno: I have put the exercises of the lectures on blackboard. I did not post the answers. I hope this will motivate the students to attend the lectures.*

E "Smiley"

F "Extra lectures each week discussing example of exercises?"- *response Arno: I believe the balance is ok.*

G "Was not able to attend all lectures due to scheduling conflicts with other courses. Otherwise great course!"

H "I really liked the enthusiasm displayed on edX, it made it far more enjoyable"-

I "Videos are brilliant"

J "I really like this concepts I could spread my time in my own way and rewatch the tough lectures."

"very good"

K "I like the fact that you can watch and re-watch the lectures whenever you like"

L "Would like more information about degradation of PV cells *response Arno: This topic is too much detailed for an introduction course.*

M "was TOP!"

N "Heel goed dat de filmpjes zo'n hoge informatie dichtheid hebben. Zo kan je niet afdwalen. Je bent sneller klaar met college kijken en kan meteen aan de opdrachten beginnen. Ik liep wel een beetje achter, maar het was juist fijn dat ik in de tentamenweek snel en overzichtelijk de stof kon vinden en leren ipv. Colleges van 2 uur op collegerama doorspitten."

O "Learned a lot, interesting course. Thnx!!"

P "Een compacte reader zou fijn zijn. Het boek is te uitgebreid." *cells response Arno: The book covers the content of our MSc profile. I think we can run this course without the book.*

Q "More exam exercises including answers would be fine." *comment Arno: Three old exams were provided through blackboard. I would consider that to be sufficient.*