

TEACHING DIFFERENTIAL EQUATIONS ONLINE

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ABSTRACT. An online version of the course on differential equations at Polytechnique Montréal exists since 2013. The description of this online version as well as the results obtained by the online students are presented. These results are compared to the ones obtained by classroom students. It is found that during the nine terms since the online version of the course has been offered, the online students had better results than their classroom colleagues. The conclusions that can be drawn from our experience with online teaching are discussed.

1. Introduction and course description

Because of the recent coronavirus outbreak, remote teaching has become all of a sudden widespread and ubiquitous. At Polytechnique Montréal, a “self-directed learning” version of a course was already offered in 2002; see (Baïlon *et al.* 2005).

In the case of the course of interest on differential equations, first there has been a pilot project to develop an online version of this course. In the summer of 2013, the online version of the course was offered for the first time. In the fall of 2014, the pilot project ended and the course was included in the regular course offering from the summer of 2015.

There are definite advantages to online learning. Indeed, using the Internet, online learning enables the student to have a permanent access to the course material and to communicate actively with the professor and the other students, and enables the professor to control and monitor the learning process. Moreover, with this type of learning process, there are no time restrictions and no need for classrooms (except for the exams).

Note that with the new technology, it is now sometimes possible to let the students take the exams at home and use a software installed on their computers in order to monitor them remotely; see (*ESDR* 2020) and (*LOPS* 2020). Therefore, the course could be taken by students who are located anywhere in the world.

The course format for the online version is slightly different from the standard version of the course. Contrary to the standard version, there are weekly assignments. However, the exams are the same as the ones in the standard course. There is a discussion forum and a bank of questions with answers.

At the end of the term, the same thresholds are used to determine the letters (from A* to F) that the students will receive. Since every student can choose to take the online version of the course, the different formats do not cause any problem.

The course material was divided into themes, and for each theme a video clip lasting between 5 and 15 minutes was produced. In Figure 1, a screenshot of such a video is presented.

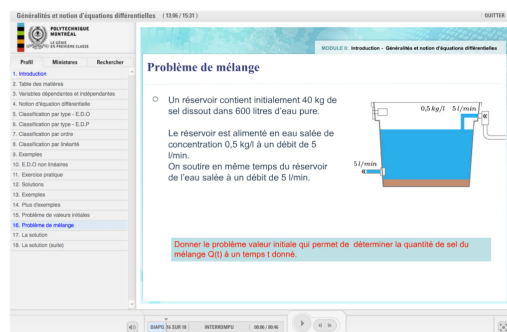


FIGURE 1. Screenshot of a video clip.

As can be seen in Figure 2, the percentage of students choosing the online version of the course is quite large, particularly during the summer terms (that is, S2014, S2015 and S2016), where it has steadily increased.

Number of students registered			
Term	Online	Classroom	TOTAL
S2013	21 (27%)	56	77
F2013	35 (8%)	398	435
W2014	76 (20%)	308	381
S2014	63 (54%)	53	116
F2014	66 (18%)	309	376
S2015	64 (59%)	45	109
F2015	95 (32%)	200	295
W2016	126 (41%)	179	305
S2016	54 (64%)	30	84
F2016	100 (37%)	170	270

FIGURE 2. Evolution of student enrollment.

The students who choose the online course come from every program at Polytechnique Montréal. There are also students from other universities. The course is especially popular among students who are experiencing difficulties (and taking the course for the second or third time), exchange students and those enrolled in the Sports Studies program.

Finally, the students who took the online version of the course were generally satisfied with this learning process.

2. Students' results

At Polytechnique Montréal, like in many universities in North America, a letter grading scale is used: F (= 0 over 4), D (= 1), D^+ (= 1,5), C (= 2), C^+ (= 2,5), B (= 3), B^+ (= 3,5), A (= 4), A^* (= 4).

In Figure 3, the results obtained by the students who took the online version are compared to the results obtained by those who followed the classroom course.

AVERAGES OBTAINED BY THE STUDENTS

Term	Online	Classroom
S2013	2,45/4	1,40/4
F2013	2,19/4	1,97/4
W2014	2,25/4	1,84/4
S2014	2,78/4	1,55/4
F2014	2,43/4	2,17/4
S2015	2,08/4	1,42/4
F2015	1,93/4	1,85/4
W2016	2,35/4	2,18/4
S2016	2,18/4	1,84/4

FIGURE 3. Students' result.

We see that the averages for the online students were always better than the corresponding ones for classroom students. The differences were sometimes quite large, again especially during the summer terms. This fact could perhaps be explained by noting that there is always a relatively large number of students in the summer who take the course for the second or even third time. However, in Figure 4, we can see that the students who took the course for the second or third time did indeed relatively well, but not better (on average) than those who took the course for the first time.

AVERAGES OBTAINED BY STUDENTS WHO TOOK THE COURSE FOR THE FIRST TIME OR NOT

Term	1 st Time	2 nd or 3 rd Time
S2013	2,72/4	2,25/4
F2013	2,10/4	2,36/4
W2014	2,58/4	2,18/4

FIGURE 4. Results according to the profiles.

Since the use of online teaching is bound to become more and more widespread, whether by choice or necessity, the results presented in Figure 2 are very encouraging.

3. Conclusion

Here are some conclusions that can be drawn about online teaching of the course on differential equations at Polytechnique Montréal:

- the students who choose the online version have a larger success rate than the ones taking the standard version;
- the format of the course enables the professor to evaluate the students gradually and frequently, without increasing their working load;
- thanks to the quick and frequent feedback, the professor can follow, accompany and well supervise the students during the learning process.

The above conclusions are positive. There are however some points that need to be watched carefully. Firstly, there is a high rate of absenteeism during the virtual classes. Secondly, some students are not motivated and diligent enough; in particular, some decide not to do the compulsory assignments. Thirdly, the technical requirements to produce the online version can be quite demanding.

As future work, we should update the data set, by using the results from the academic years 2017 to 2019. We should also perform some statistical tests to determine whether there is a *significant* difference between the results obtained by the students taking the online version and the standard version of course.

Acknowledgments

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References

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