Moving Classes in a Large Programming Course Online: An Experience Report

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Abstract

We present an experience report on moving face-to-face classes in a large CS1 course to an online format, during the COVID-19 pandemic. The course is based on the flipped classroom approach and team-based learning. Students prepare for classes by reading specific chapters of the textbook and/or by watching pre-recorded videos. The classes are synchronous, in which students take quizzes and work on programming assignments in teams, with the guidance of tutors. To evaluate the implementation, we compared the results from surveys and exams between 2019 and 2020. The results show that students were at least as satisfied with the online classes in 2020 in comparison with face-to-face classes from the previous year, and generally satisfied with the organization of the course and the learning experience. Moreover, we found no discernible change in the grades on the midterm exams and the final exam between the two years. In the future, we might allow the students to choose the class format that best fits their individual needs.

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1 Introduction

During the last decade, teaching, learning, and collaborative approaches have become important topics in introductory programming education research [2]. The flipped classroom (FC) is a teaching approach in which the emphasis is on active learning. In the FC, students are expected to study specific course material outside the class, and then engage in learner-centered activities in the classroom with the help of (a) tutor(s) [1, 4, 12, 17, 18, 19, 22]. Active learning often involves Team-Based Learning (TBL) (or Project-Based Learning (PBL)) where students work on projects in a collaborative manner in groups [8, 9, 20].

Overall, the last couple of years have been very stressful, with extra workload for university faculty and staff, as well as for the students. The COVID-19 pandemic has affected the entire educational system world-wide, and most face-to-face courses at the university level were at one point moved to an online format, often within a short notice.

In this paper, we present a detailed experience report about moving face-to-face classes in a large CS1 course, which was already based on FC and TBL, to an online format. Our motivation for moving the classes online was purely due to necessity, i.e. due to the COVID-19 pandemic. However, moving classes to an online format can be beneficial, in general, as pointed out by Irani and Denaro [7]: "The flexibility of an online class makes it easier for students to schedule the coursework around other commitments, and commuting students can save time in not traveling to campus for every class".

Our online classes are *synchronous* in the sense that students and teachers meet in real-time, with the help of a video-conferencing platform, at specific slots in the time table. This mode of classes, which has also been called "online face-to-face" [6], is in contrast to *asynchronous* online learning which does not require students and teachers to be online at the same time [19].

Our surveys show that students were at least as satisfied with the online classes in comparison with face-to-face classes from the previous year. Moreover, we found no discernible change in the grades on the midterms and the final exam between the two years.

We believe that the work described in this paper can be beneficial to teachers of CS1 courses who want to apply FC and TBL in their online courses.

This paper is organized as follows. We discuss related work in Section 2, present background for our work in Section 3, and the moving of our classes online in Section 4. The results and discussion regarding student surveys and exams are presented in Section 5 and 6, respectively. Finally, a conclusion is presented in Section 7.

2 Related work

2.1 The Flipped Classroom

Learning programming can be difficult for many students, which often leads to high failure and drop-out rates from programming courses [15]. Consequently, several CS departments have experimented with using the FC teaching method in introductory programming courses. In the FC, the "traditional" lecture is replaced with in-class activities and students are supposed to come prepared for class by watching pre-recorded videos and/or reading given text material. In what follows, we briefly review a few of the recent papers that have shown benefits of using an active learning approache like FC in introductory programming courses.

Elmaleh and Shankararaman [4] report on the impact of implementing a course, with 280 students, using FC. They observed that in comparison to a previous "traditional" running of the course, the FC increased pass rates in the final exam and also enhanced competency acquisition.

Wang et al. [22] present an experience report about using FC and PBL in a course with 132 students. They show that the adoption of FC and PBL brought significant enhancement to students' performance in the final exam, compared to previous "traditional" running of the course. However, they also experienced inadequate preparation before class by some of the students and lack of enthusiasm in classroom interaction.

Mohamed [12] evaluates the extent to which FC, combined with pair programming, enhances students learning in a relatively small (90 students), mixed-ability CS1 course. The study showed that the use of FC increased the average class grade, pass rate, and course ratings compared to a previous corresponding non-flipped course.

Battestilli et al. [1] present preliminary results, from a course of 219 students, in which significant differences in students' performance is identified based on how active they are in the online activities offered as part of the FC approach.

Sprint and Fox [18] present the implementation of a FC, gamified CS1 course, designed to motivate students to improve their study habits. The study showed that students in the FC course submitted programming assignments and online quizzes earlier and with fewer late submissions compared to students in a "traditional" course. Nevertheless, these improved study choices did not lead to higher final exam scores.

2.2 Online Courses

Students, teachers, and authorities had to adapt quickly to new pedagogical models and organisation of teaching delivery in 2020. Higher education institutions were informed by government mandates, executive orders, or recommended best practices to convert the modality of instruction to an online learning platform [5, 16].

Despite the fact that online courses have become increasingly popular at universities in the last few years [7, 19], the literature only contains (to our best of knowledge) a few recent papers about converting face-to-face classes to an online format for specific CS courses.

Irani and Denaro [7] describe their experience in creating an online course, with active learning strategies, in Discrete Mathematics and compare it to a corresponding "traditional" face-to-face course. They found no discernible difference in student performance between the two class versions.

Subramanian and Budhrani [20] redesigned an object-oriented systems face-to-face course as an online course. The content of the course was retained, while its structure was significantly modified to use a PBL approach. They found that various factors are critical for a successful online course, e.g. course structure, content scope, project design, assessment design, instructional resources and tools.

Related descriptions and studies can be found in other fields. Wang and Goryll [21] discuss the experience of changing a face-to-face 15-week lecture-lab Digital Design course to online format. Student retention and performance was similar between the online and the face-to-face course, and students reported overall satisfaction with the online course. Suggested improvements are related to development of course materials, better student support and integrating teamwork in the course.

Gottipatti and Shankaraman [5] present how a Master's degree course in Text Analytic and Applications was rapidly moved over to an online format during the COVID-19 crisis. The lesson learnt was that changing a course from face-to-face to an online format is not an easy task, and that students' feedback is valuable in the design process. The results suggested that it might be necessary to reduce the course content when using an online form, that the instructor needs time to learn how to master advanced features of the technology tools, and the student also need time to adjust to new methods of studying. Student evaluation showed that a large majority of the students were satisfied with the online course.

Roy and Covelli [16] describe moving courses in a liberal arts institution from a face-to-face format to an online format when half of the semester had passed. They found that the move, for both faculty and staff, was easier for those with prior experience with an online format and/or for those who felt comfortable with an online format. Moreover, a majority of the students expressed less interest than before in taking online classes.

Grimmer et al. [6] investigated the transition to online teaching (when the semester has already started) in an academic literacies course, and how to use the experience both for future online and face-to-face courses. They recognised online methods that could be used in face-to-face environment e.g., online classroom chat in lectures. The retention rates of their face-to-face students that were forced into the online learning environment was in line with the last five years in face-to-face learning in the course.

3 Background

The CS1 course at Reykjavik University is a large course. In fall 2020, 502 students, mainly from the departments of CS, Engineering, and Business, registered for the course. The students from CS take the course during their first semester, while the students from Engineering and Business pursue the course in their third semester. Our CS1 course thus "attracts a diverse crowd of students who bring mixed abilities and backgrounds to the classroom" [12].

The course does not assume any prior programming knowledge and uses Python to introduce fundamental CS1 programming concepts, e.g. variables, types, control structures, and functions, as well as built-in data structures like strings, lists, and dictionaries. The

concept of a class is introduced and how it supports encapsulation and information hiding in the context of object-oriented programming. Students learn to use both an Integrated Development Environment (IDE) and command prompt mechanisms for the development and execution of programs.

In [10], we described our experience and the results of using a FC and a TBL approach in an introductory programming course during fall 2018. In fall 2019, we presented several improvements to the course [11], e.g. we reduced the pressure of submission of assignments during classes, emphasized textbook reading to a greater extent, showed short videos at the beginning of each class, and provided the students with several videos (for the student to watch at home) that demonstrated how to apply functional decomposition. A comparison of the results from student surveys given in both years showed that students were in general satisfied with the changes made and the performance on the exams was better in 2019 compared to 2018. The implementation in 2019 can be summarized as follows:

- One faculty member, the main instructor, was responsible for the overall organization of the course (syllabus, assessment, quizzes, projects, exams, etc.).
- The students were divided into several sections, with 50–70 students in most sections. Inside each section, the students were divided into teams of 5–6 students. Each section met two days a week in class, for four lecture hours each day. Each section/class had one teacher and one teaching assistant (TA) as facilitators and tutors. Whenever the students had a question they could ask the tutors for help.
- Students were supposed to come prepared for classes by reading specific chapters of the textbook [13] and, in some cases, by watching a video (made by the main instructor).
- At the beginning of each class, a 15–25 minutes video (made by the main instructor) was shown in each of the sections. Each video gave an overview of the concepts to be discussed/worked on in the class.
- A short individual quiz, containing ten multiple-choice questions, which were directly linked to the given textbook material and the video, was given in most of the classes after the video had been played. Thereafter, students discussed the same quiz in their teams, which turned in a single collective answer for each of the questions.
- For the remainder of the class, the students were given several short programming assignments to work on in the teams. Students were encouraged to work together on the solutions, but each student needed to submit his/her solution before the class finished. Students' solutions to each assignment were graded using automatic tests.
- In addition to the short programming assignments given during class, the students were given larger programming projects each week to be worked on at home, optionally in a group of two students.
- *Mimir Classroom*[1] was used for quizzes and programming assignments/projects. The quizzes and programming assignments in class were automatically graded by Mimir, whereas the weekly programming assignments were graded by a group of TAs. *Piazza*[2] was used as the question-answering platform, and *Canvas*[3] as the Learning Management System.

The results from the student surveys, presented by the authors in [11] show that, overall, the students in the programming course liked to work in teams with fellow students, that the discussion with fellow students in class helped them to learn, and that they felt that communication with teachers in class helped them to study.

[1] `https://www.mimirhq.com/`
[2] `https://www.piazza.com/`
[3] `https://www.instructure.com/canvas/`

4 Moving Classes Online

In light of the successful implementation described in Section 3, we intended to use the same format for the course in fall 2020. However, due to the COVID-19 pandemic, we needed to move the classes online. The main challenge we faced was how to exercise both TBL and FC when face-to-face classes were not allowed. We were indeed quite worried that applying these teaching methods would not turn out to be successful, when running the classes online.

In order to emulate a face-to-face class with student teams in each class, we used Zoom[4] and its *breakout room* functionality. One recurring meeting (twice a week) was created in Zoom for each of the student sections. In addition, one (Live Q/A) thread was created in Piazza for each section for each meeting. Our course had nine sections, with about 55 students, on average, in each section.

Each typical synchronous meeting/class was run in Zoom in the following manner:

- At the beginning of each class, the teacher and the TA "met" all students in the main room. The teacher started the class with an overview of the schedule for the day and then played a pre-recorded, short video (see Section 3), in which an overview was given of the concepts to be discussed/worked on in the class.
- After the video had been played, students were able to ask questions before the quiz started in Mimir. In addition to the individual quizzes, in 2018 and 2019 we had used team quizzes as well, implemented with Immediate Feedback Assessment Technique (IF-AT) scratch cards [10, 11]. Because these cards are "physical" cards, we were not able to include the team quizzes in our online classes.
- Once the quiz was finished, the programming assignments were opened in Mimir, to be worked on in the teams. Each team was given a separate breakout room in Zoom. At the beginning of the semester, students were randomly allocated into teams, but after about three weeks the students were allowed to form their own pre-defined teams. If a pre-defined team consisted of less than five students, the teacher moved students, not belonging to any team, into the pre-defined ones by using the corresponding functionality in Zoom. When students in a breakout room needed help, they posted a help request on the corresponding Piazza thread, monitored by the teacher and the TA.
- The teams were not given any special instructions on how to work collaboratively on the programming assignments in class. In some cases, each team member wrote his/her own code and mainly shared ideas in the breakout rooms. In other cases, the team members applied pair/tri programming. As mentioned in Section 3, before the end of the class each team member needed to submit his/her solution in Mimir. Visual Studio Code[5] was used as the main programming development environment.

Apart from the use of Zoom, the organization and implementation of our course closely follows the one presented in Section 3.

However, there is one other difference. In [10], we specifically noted that there were two "problems" with students with previous programming knowledge, who are, in most cases, male students. First, some of the female students felt intimidated by these male students in the team work. Second, many of the students with previous programming knowledge felt bored during the first weeks of the course, because the material was too elementary for them.

[4] Zoom is a video-conferencing solution which supports high quality point-to-point and multi-party video conferencing, content sharing, and group and individual chat [14].

[5] `https://code.visualstudio.com/`

Table 1 Student assessment.

Item	Weight
Quizzes in class	10%
Programming assignments in class	10%
Weekly programming projects	20%
Two midterms	0–20%
Final exam	40–60%

Table 2 Answers to the question "Are you generally pleased or displeased with the course?".

Rating	Answer	Count	Ratio
5	Very pleased	116	36.3%
4	Rather pleased	121	37.8%
3	Moderate	53	16.6%
2	Rather displeased	22	6.9%
1	Very displeased	8	2.5%

We decided to implement our own suggestion put forth in [10], i.e. by making a special section for students with previous programming knowledge and present additional, more challenging, programming assignments to them. The establishment of this special section was announced a week before the course started and participation in the section was optional. About 60 students, of the 502 starting the course, signed up for this special section.

As we pointed out in [10], a FC/TBL version of a large CS1 course demands considerable effort and manpower. In our course, in addition to the main instructor, we had 16 teachers and TAs in the nine sections, eight TAs graded the weekly homework assignments, two TAs took care of a special helping session once a week, and two TAs were hired to specifically help the main instructor to answer questions on Piazza. Thus, about 30 persons contributed to the running of the course in some way or another.

The students' assessment consists of the five items shown in Table 1. To obtain full points for the programming assignments in class, the students needed only to pass 50% of the automatic tests, on average, during each class. This rule was introduced in 2019 to reduce the pressure many of the students felt when needing to submit solutions to all assignments during each class [10]. Each of the two midterm exams weighted 10%. However, if the student obtained a higher grade on the final exam than in one or both of the midterm exams, the weight of the final exam increased to either 50% or 60% and the corresponding midterm weight dropped to 0%.

5 Surveys

In this section, we present and discuss the results of two surveys carried out among students registered in the course.

5.1 First survey

The first survey (student evaluation) was administered by the Office of Teaching Affairs and was given to students in the fifth week of the course. At that time, 485 students were still registered in the course, of which 320 students (66%) participated in the survey. Students were asked to answer a single question rated on a five point Likert scale. The question and the results are presented in Table 2.

According to the results, 74.1% of the students were pleased (either very pleased or rather pleased) with the course, and only 9.4% displeased (rather displeased or very displeased). The weighed average is 3.98. These results are very similar to the ones obtained for the same question in the course in fall 2019, where 76% of the students were pleased with the course, 7% displeased, and for which the weighted average was 4.0 [11]. According to this comparison, moving the classes online did not affect students' satisfaction in the first weeks of the course.

5.2 Second survey

In order to evaluate students' attitudes, experience and learning, we constructed a detailed survey, consisting of 28 questions, which students answered during weeks 9–10 of the course. At that time, 473 students were still registered, and 305 students (64.5%) provided answers to the questions. We used the questions from the 2019 course [11], but, in addition, we added a few questions connected to the fact that our classes had been moved online.

We divide the questions into four main categories: *Course organization and teaching* (nine questions), *Study materials and midterms* (six questions), *Cooperation and communication* (four questions), and *Use of systems* (four questions)[6]. Where applicable, in the tables we provide the results from the same questions in fall 2019, in parentheses, i.e. "(19)". In Tables 3–6, the columns "Totally agree", "Agree", "Neutral', "Disagree', and "Totally disagree' correspond to points 5–1, respectively, on the Likert scale.

By considering the results presented in Table 3, we see that the responses are very similar between 2020 and 2019 (a t-test between the mean scores of the two years revealed no significant difference in any of the nine questions). Students are generally satisfied with the organization and the learning experience in the course: 66% of the students agree (sum of columns "Totally agree" and "Agree") that the organization of the course is good (question one), and 69% agree that the course is overall a good learning experience (question two). The results from the first survey, presented in Table 2, show that about 74% of the students were pleased with the course after five weeks. It is understandable that satisfaction drops a bit when the course progresses, because the material gradually becomes harder. When considering the results from questions one and two it can be deduced that by moving the classes online has not reduced students' satisfaction between the years 2019 and 2020.

It is interesting that, despite the general satisfaction among students, 42% agree that the course lacks traditional lectures (question four) and that only about half of the students agree that using the FC is suitable for the course (question five). On the other hand, note that only 14% disagree that using the FC is suitable.

According to the answers to question nine, 54% of the students agree that moving the classes online is suitable, whereas 31% disagree. Due to the general satisfaction with the organization and the learning experience, one might be inclined to keep this online format of the classes in the future, but one may have to take into account that about one-third of the students disagree of the suitability of the online move.

According to Table 4, 55% of the students in 2020, compared to 48% in 2019, feel that the textbook helped in their studies (question 10). At the beginning of our course, we specifically emphasized the importance of the textbook and that students should come prepared for classes by reading given chapters of the text. Nevertheless, according to question 11, only 47% of the students usually read the textbook before class and this figure is a bit lower compared

[6] In the accompanying tables, we skip five questions that mainly concern students' background.

Table 3 Course organization and teaching.

Question	Totally agree 20 (19)	Agree 20 (19)	Neutral 20 (19)	Disagree 20 (19)	Totally disagree 20 (19)
1. The organization of the course is good	26% (20%)	40% (42%)	22% (23%)	7% (12%)	5% (3%)
2. This course is overall a good learning experience	36% (33%)	33% (34%)	17% (18%)	10% (9%)	5% (6%)
3. The classes each week are useful to me	28% (29%)	30% (29%)	23% (20%)	14% (16%)	5% (6%)
4. The course lacks traditional lectures	24% (25%)	18% (17%)	21% (19%)	17% (19%)	20% (20%)
5. I feel that the flipped classroom is a suitable approach in this course	24% (24%)	24% (29%)	38% (24%)	7% (12%)	7% (10%)
6. I like the assessment of the programming assignments in class	49% (43%)	30% (29%)	13% (16%)	5% (6%)	3% (6%)
7. The programming assignments in class are in accordance with the teaching material	35% (37%)	31% (32%)	17% (14%)	9% (10%)	8% (7%)
8. The weekly progr. projects are in accordance with the teaching material	30% (27%)	28% (25%)	20% (20%)	13% (16%)	9% (12%)
9. I feel that moving the classes online is suitable in this course	33%	21%	16%	14%	17%

to 2019. Note that a substantially higher ratio of students watch the videos before/after class (question 13), compared to the ratio of students reading the textbook. For Table 4, a t-test between the mean scores of the two years revealed no significant difference.

The fact that less than 50% of the students read the textbook before coming to classes is worrying, but not surprising. For several years, we have noticed a gradual decline in textbook reading by our CS students. According to Brown et al. [3], "one issue that plagues millennials is the lack of focused, in-depth reading to achieve understanding", and "one of the biggest challenges instructors have dealt with for many years is getting students to read their required textbooks".

Table 5 (question 16) shows that a lower ratio of students in 2020 (63%) compared to 2019 (73%) agree that discussing with fellow students helped their studies (a t-test between the mean scores of the two years only revealed a significant difference for this question (t-value 3.11, $p < 0.01$)). This may indicate that the communication between students in the Zoom breakout rooms is not as straight-forward as it is when communicating in person. The teachers noted that in some teams the communication between students in the breakout rooms was generally active and that they worked collaboratively, while in other teams it seemed that the students worked rather as individuals. On the other hand, the responses to question 19 show that a higher ratio of students in 2020 (62%) compared to 2019 (55%)

Table 4 Study material and midterms.

Question	Totally agree 20 (19)	Agree 20 (19)	Neutral 20 (19)	Disagree 20 (19)	Totally disagree 20 (19)
10. The textbook of the course helped me in my studies	22% (25%)	23% (23%)	25% (28%)	17% (16%)	12% (8%)
11. I usually read the book before the class	26% (33%)	21% (19%)	18% (18%)	13% (11%)	21% (19%)
12. The videos of the course helped me in my studies	23% (24%)	33% (28%)	26% (27%)	12% (16%)	7% (5%)
13. I usually watch the videos given before/after the class	42% (42%)	25% (27%)	20% (16%)	6% (10%)	7% (5%)
14. I like taking a quiz at the beginning of class	18% (19%)	30% (31%)	28% (23%)	13% (14%)	12% (12%)
15. I like the arrangements of the midterm exams	53% (57%)	31% (31%)	11% (8%)	3% (0%)	1% (3%)

feel that communication with the instructors in class helped their studies. The difference between the mean scores of the two years for this question is not statistically significant, but it may be the case that it is easier for a student team to communicate with a teacher inside a breakout room as opposed to the team sharing a large physical classroom with all other students (as in 2019).

Table 6 shows that students are generally happy with the support systems used in the course. However, there is a large reduction of satisfaction in Piazza usage (question 21) in 2020 (46%) compared to 2019 (63%). This is difficult to explain, but we conjecture that students did not like to ask teachers to "visit" them in Zoom breakout rooms by posting such a help message in Piazza, where it can be seen by everyone. Unfortunately, in the Zoom version we used, it was not possible to post a message to the host or co-host (teacher or TA) from within a breakout room. This is the reason why we used Piazza for this purpose. For Table 6, a t-test between the mean scores of the two years only revealed a significant difference for question 21 (t-value 4.11, $p < 0.001$).

6 Exams

In this section, we present the implementation of the two midterm exams, the final exam, and the retake exam given in the course along with exam results. All four exams were set up in Mimir, and students were able to receive assistance by using Piazza and Zoom. If a student needed assistance during an exam, he/she posted a request in a given Piazza thread and, consequently, the teacher or the TA moved the student into a breakout room in Zoom.

The exams were "open book", in the sense that students were allowed to use the textbook, slides, notes, and solutions to assignments in the exam. Students were, however, neither allowed to use web search nor any kind of communication software during the exam. Grades are given on a 0–10 scale, and a grade below 5 is a failing grade.

Table 5 Cooperation and communication.

Question	Totally agree 20 (19)	Agree 20 (19)	Neutral 20 (19)	Disagree 20 (19)	Totally disagree 20 (19)
16. Discussing with fellow students in class helped me in my studies	35% (44%)	28% (29%)	19% (16%)	9% (6%)	9% (4%)
17. Discussing with fellow students outside class helped me in my studies	35% (39%)	31% (31%)	22% (20%)	7% (4%)	6% (6%)
18. I like to work in a group with fellow students	35% (38%)	27% (29%)	21% (19%)	10% (8%)	7% (5%)
19. Communication with instructors in class helped me in my studies	28% (32%)	34% (23%)	21% (26%)	12% (12%)	5% (8%)

Table 6 Use of systems.

Question	Totally agree 20 (19)	Agree 20 (19)	Neutral 20 (19)	Disagree 20 (19)	Totally disagree 20 (19)
20. I like to use Canvas	37% (39%)	33% (29%)	26% (26%)	2% (4%)	1% (2%)
21. I like to use Piazza	23% (34%)	23% (29%)	26% (24%)	16% (5%)	12% (8%)
22. I like to use Mimir	45% (52%)	36% (30%)	10% (13%)	4% (3%)	5% (2%)
23. I like to use Zoom	31%	31%	19%	11%	7%

The plagiarism software *Moss*[7] was run on student solutions. We found some plagiarism cases in the midterm exams. These cases were reported (resulting in the grade 0) and, consequently, the seriousness of plagiarism was discussed with the whole student body on Piazza. As a result, we did not find any obvious cases of plagiarism in the final exam.

We used the timing and the material for the exams described in [10]:

> The first midterm exam was given in the fourth week of the course. The material for the exam were basic programming concepts like variables, types, operators, assignment statements, expressions, if-statements, and loops. The second midterm exam was given in the eighth week of the course. In addition to the material covered in the first exam, the second one included the following concepts: functions and top-down refinement, scope, file I/O, exception handling, lists and tuples. At the time of the final exam, the following concepts had been added: dictionaries, sets, (large) program development, and classes.

The duration of the first midterm exam, the second midterm exam, and the final/retake exam, was 2 hours, 2.5 hours, and 3 hours, respectively.

Table 7 shows the results from the four exams – the numbers in parenthesis show the results from the 2019 course[8]. The number of students still registered in the course at the time of the four exams were 485, 474, 463 and 463, respectively. According to our experience,

[7] `https://theory.stanford.edu/~aiken/moss/`

[8] The student body and the difficulty of the exams in the courses in 2019 and 2020 are very similar, which justifies making a direct comparison.

Table 7 Exam results.

Exam	Students 2020	Average grade 2020 (2019)	Failure rate 2020 (2019)
Midterm 1	462, 95.3%	8.9 (8.5)	3.5% (8.1%)
Midterm 2	433, 91.3%	5.8 (6.0)	36.7% (39.6%)
Final	401, 86.6%	6.0 (5.9)	35.4% (33.9%)
Retake	125, 27.0%	4.9 (4.0)	39.2% (52.7%)

the participation in the second midterm exam is a good indicator of the dropout rate in the course. In 2019, 82.8% of the registered students (at the start of the course) showed up in the second midterm, whereas the corresponding ratio in 2020 was 86.3%.

It is noteworthy how much the average grade decreases in midterm 2 in comparison to midterm 1, and, consequently, how much the failure rate increases. This is consistent with the exam results for the 2019 course. The reason is that the material covered on the first midterm exam is relatively easy for most students, whereas the second midterm exam covers more complex concepts.

As mentioned in Section 4, students with previous programming experience were given the opportunity to take part in a special section intended for this group of students. The average grade on the final exam for students in this special section was 8.4, compared to 5.7 for the students in the other sections. This difference in final exam performance in CS1 between students with and without previous programming experience is even greater than, for example, the results presented in [24].

The grades in the two midterm exams and the final exam in 2020 are very similar to the corresponding grades from the 2019 course. We thus deduce that moving our classes online did not significantly affect students' performance.

Of the 502 students that were registered at the start of the course, 353 students (70.3%) passed the course (either the final exam or the retake exam). The corresponding failure rate of 29.7% is a bit lower than the mean worldwide failure rate of 32.3% presented in [23].

7 Conclusion

In this paper, we presented an experience report on moving the classes in a large CS1 course, emphasising FC and TBL, to an online format in 2020. The motivation for the move was the COVID-19 pandemic. A priori, we were worried that moving the classes online would make it difficult to successfully use the FC and TBL teaching and collaborative approaches in our programming course. However, our experience shows that conducting these methods in online classes did not pose any special problems in comparison to face-to-face classes.

We presented the results of two surveys and four exams. According to the surveys, students were generally satisfied with the organization of the course and the learning experience. A comparison of the results to the course from the previous year shows that moving the course online did neither have negative effects on students' attitudes nor on students' grades.

When the on-going pandemic is over, we need to make a decision on whether to move back to face-to-face classes in our CS1 course. It might be an option to continue giving the classes online in the future. One argument against online classes is that, according to our results, a lower ratio of students in these classes feel that discussing with fellow students helped their studies, compared to the similar face-to-face class course from the previous year. On the other hand, our results also show that a higher ratio of students in the 2020 course, compared to the course in 2019, feel that communication with the teachers in class helped their studies.

Finally, the best option may be to allow students to choose the class format that best fits their individual needs, i.e. allowing students to choose either online classes or face-to-face classes.

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