Integrating Flipped Classroom Approach and Work in Pairs into Workshops in Programming Course

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Abstract – *Active learning approaches have been suggested by many academics for improving students learning to program. This paper describes an attempt to integrate flipped classroom, collaborative learning and peer review approaches into workshops in a compulsory first-year object-oriented programming course. The students in our course have to read the workshop material and solve some problems outside the class. In the workshop, the students work in pairs, and review and correct the homework of each other together. Students were surveyed to obtain their views on the work in pairs and flipped classroom approach in the workshops in the programming course. Results indicate the student's positive attitude to such organization of workshops.*

Keywords: flipped classroom, collaborative learning, work in pairs, peer review, programming learning, workshops.

1 Introduction

Learning to program can be very hard [10]. Different approaches are used to make learning easier. Lately, much attention is paid to using student-centered active learning approaches instead of traditional teacher-centered approaches. Different techniques are presented to support student learning using student-centered approaches. Flipped classroom and collaborative learning are some of them.

The flipped classroom approach, introduced in 2000 by Baker [3] and Lage et al. [11], means that events traditionally taking place inside the classroom are organized outside the classroom and vice versa. This approach is usually applied to lectures where students watch video lectures at home, and discuss and solve the exercises in class. However, Bishop and Verleger found in their survey of research [5] that "students tend to prefer in-person lectures to video lectures, but prefer interactive classroom activities over lectures". The present paper describes an attempt to integrate the flipped classroom approach into workshops, leaving lectures in the class, in a compulsory first-year object-oriented programming (the second programming) course at the University of Tartu, Estonia. Traditionally workshops mean that students read the materials (tutorials) and solve the problems weekly in the class and teachers correct the problems and give feedback after class. This is what we did for years. As the groups are quite large (usually we have around 200-250 students) the correction and giving feedback can take a lot of time. Some courses are using automated assessment systems (like VPL, the Virtual Programming lab for Moodle [16]). We wanted to engage students in this process.

Students' engagement in the learning process is one of the key moments in active learning [15]. There exist different types of active learning, like peer-assisted learning, collaborative learning, cooperative learning and problem-based learning. We use a mixture of collaborative learning and peer review. The students in our course have to read the workshop material and solve some problems alone outside the class (flipped classroom). In the class, the students work in pairs (collaborative learning), and review and correct the homework of each other together (peer review). In addition, they fill out the worksheet with questions about programs. After that, the students solve additional problems.

This paper describes the organization of the course and its history (how we came to this solution). There are two specific research questions of interest. What do the students think about the work in pairs in the programming workshop? What do the students think about flipped classroom in the workshop? Both of these questions are answered using a survey of students taken in 2015. In addition, we asked the instructors of workshops for their opinion on this organization of workshops.

The paper has the following structure: Section 2 gives an overview of related works, in particular in using flipped classroom and active learning approaches. The organization and history of the course and conduct of the survey for answering the research questions are thoroughly described in Section 3. The results of the survey are provided in Section 4. Section 5 concludes the paper.

2 Related works

Reviewing the literature, Andrews et al. [2] found that "there is a consensus among education researchers that much of the difficulty students have learning science can be attributed to the passive role students play during traditional lectures". They also found that active learning could improve learning. They said: "A classic example of active learning is a think–pair–share discussion, in which students think about a question posed by the instructor, pair up with other students to

discuss the question, and share answers with the entire class." A very good overview of active learning is provided by Prince [15]. Prince defined common forms of active learning, which are most relevant for an engineering faculty, and examined the evidence for effectiveness of active learning. Prince defined active learning as "any instructional method that engages students in the learning process" and described, "active learning requires students to do meaningful learning activities and think about what they are doing". The definition of collaborative learning provided by Prince is the following: "Collaborative learning can refer to any instructional method in which students work together in small groups toward a common goal". Prince's study has found support for all forms of active learning examined and has presented the benefits of student engagement. Likewise, Michael [13] found that "there IS evidence that active learning, student-centered approaches to teaching physiology work, and they work better than more passive approaches".

Active learning approaches to teaching and learning programming are also under discussion and concern in different papers. Barg et al. [4] have designed problem-based learning (PBL) courses (one of them was Introduction to Programming) and have found that a larger proportion of trial students expressed a positive attitude to learning and a positive feeling about the course. O'Kelly et al. [14] found: "An intangible effect that we have observed is the support mechanism that has resulted from the PBL workshops. Through these workshops, students had the opportunity to get to know each other better, and to recognise how other students approach and represent a problem. We believe that this has been of significant benefit to the students." Zhang et al. [22] suggested that, "when teaching introductory programming courses, instructors may want to consider choosing the student-centered active learning over the traditional lecture format in order to improve students' learning performance".

Other very useful active learning approaches include peer assessment and peer review. Topping [20] provided a review of peer assessment and defined peer assessment as "an arrangement in which individuals consider the amount, level, value, worth, quality, or success of the products or outcomes of learning of peers of similar status". Many previous efforts to apply peer assessment and peer reviewing in computer science have involved web-based (online) peer assessment – reviewing tools. Sitthiworachart and Joy [17] described peer assessment as "a method of motivating students, involving students discussing, marking and providing feedback on other students' work". After developing and evaluating a web-based peer assessment tool for an undergraduate programming class, they found that "computer-mediated peer assessment is a valuable assessment approach which promotes active learning". Wang et al. [23] developed an online assessment system called EduPCR and after using it found that student learning in various aspects had significantly improved. Søndergaard and Mulder [18] examined student peer review rather than peer grading and listed the benefits also for the feedback provider with special consideration of computer science and software engineering. They concluded, "student peer assessment is a worthwhile exercise". Turner et al. [21] described the positive effects of peer code review in teaching object-oriented programming.

A quite recent active learning approach is flipped (also called inverted) classroom approach, which was introduced in 2000 by Baker [3] and Lage et al. [11]. In the broadest sense, flipped classroom represents a re-ordering of classroom and at-home activities. Bishop and Verleger [5] provided a survey of the research of flipped classroom. They proposed that flipped classroom actually represents an expansion of the curriculum, rather than a mere re-arrangement of activities, as group-based and open-ended problem solving is usually added in flipped classroom. They also reported that student perceptions of flipped classroom are somewhat mixed, but are generally positive overall. Gannod et al. [9] found that the response of the students from a software engineering curriculum to the course was overwhelmingly positive, especially in regard to the use of the inverted classroom model. Butt [7] found that 75% of total respondents in a final-year course in the undergraduate actuarial program viewed flipped classroom as being beneficial to their learning experience compared to a didactic lecture structure. Conversely, Strayer [19] compared the learning environments of an inverted introductory statistics class with a traditional introductory statistics class at the same university and found students in the inverted classroom were less satisfied with how the classroom structure oriented them to the learning tasks in the course, but they became more open to cooperative learning and innovative teaching methods.

Abeysekera and Dawson [1] provided a call for research as they found that the flipped classroom approach is under-evaluated, under-theorized and under-researched in general.

3 Data and methodology

3.1 Course background

This article describes an object-oriented programming course for first-year undergraduate students at our university. This course is the second programming course and is taught during the second (spring) semester. The course is compulsory for all computer science students (around 150 students every year), as well as for mathematical statistics students, who select the computer science module. However, this course is also popular among physics and mathematics students. As a result we have around 200-250 students.

The prerequisite for the course is a course titled "Programming", which has been based on Python in the last 6 years [12], where the basic concepts of programming are introduced to students. The object-oriented programming course is based on Java. The course consists of two forms of teaching: lectures and workshops. The students have one

lecture (90 minutes) and one workshop (90 minutes) per week for 16 weeks. The first author of the paper has been involved in teaching the workshops since 2006. The second author is teaching lectures since 2012 and workshops since 2006.

Traditionally, all students of the course come together for lecture in one classroom. As we have quite a large number of students (in 2015 we have 198 students registered for our course) their background and abilities are quite different. This spring we offered three different formats of lectures for students to choose. Most students participate in traditional lectures, where the lecturer gives the lecture in front of the class. During the lectures we use clickers (student response systems) as an active-learning component to increase classroom engagement and motivation (it was found that clickers are suitable for engaging students in classroom discussion, especially in large classes [6]). The lectures are videotaped and these videos are used in the second format, which is called "nonstationarity" group. In this group, the students have to watch the video outside the class and answer some questions about the lecture. About 20 students chose the "nonstationarity" lecture format. The third format of lectures is called "intensive" group and is intended for students who are already quite good in programming. Their lecturer covers the compulsory material at a faster pace and after that they have time to study additional and more difficult material. Around 20 students preferred this format of lectures.

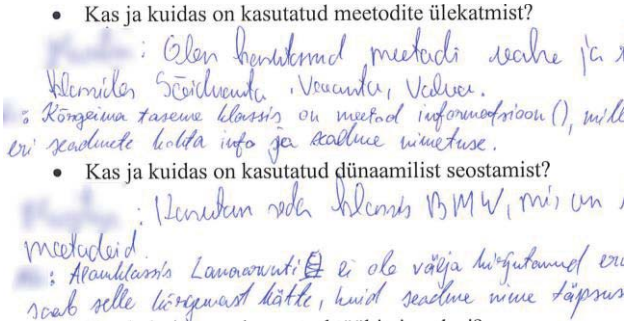
We did not use flipped classroom for the lectures because of the large number of students. We think it is very hard to interact with around 150 students in the class. Gannod et al. [9] found that "for larger classes, providing the desirable amount of instructor-student interaction would necessitate breaking these classes into smaller sections". They also proposed that flipped classroom may not be suitable for a traditional large lecture course involving hundreds of students.

3.2 Organization of workshops

Workshops play a big role in the object-oriented programming course as students can earn 54% of final grade during workshops (programming tests, homework, projects). Homework with work in pairs during workshop gave 12% of the grade. Workshops are conducted in smaller groups with around 20 students in one group with the help of several instructors. In 2015, we have seven instructors guiding the ten workshop groups.

The organization of workshops has been very variable over time. For years, we used a traditional approach, where students came to the workshop and had to read the tutorial and write some programs. The students were very passive as they were reading most of the time. The reading did not lead to a lot of question. The tutorials were quite long, with explanations and examples, and the students did not have enough time to program. The students usually had to finish their programming exercises at home. We used different ways for checking the programming exercises that were finished at home. One way was for the students to upload the programs to a web environment (e.g. Moodle) and the instructor left comments about the programs for the student there. This approach does not suit us very well, because we cannot be sure that the student himself solved the problems. Then we tried to check the programs during the subsequent workshop. The students had to come to workshop, to show the programs and to explain them. This was a good approach; the instructor had an overview of every student's skills and abilities. However, there was one problem – the instructor did not have time to explain or to answer questions. The whole time during a workshop, the instructor moved from one student to another and checked the programs.

In 2013, we decided to try the flipped classroom approach. Now the students have to read the tutorial and solve some problems before class. To solve the problem with checking the students programs and giving feedback we decided to use peer review and work in pairs. We prepared a worksheet for every workshop with questions about programs and students have to present their own solutions, to check a peer's program and to answer the questions about the peer's program. The students have to correct and improve the programs of each other together. During that time the instructor walks around in the classroom and looks at the students' programs and answers as well. After filling in the worksheet, the students have time to solve additional problems prepared for workshops. They can solve together in pairs, but they can also program separately, only asking questions from the peer and the instructor. The instructor can also solve some problems with the whole class. This means that students get more practice of programming due to flipped classroom as Bishop and Verleger [5] proposed.


• Kas ja kuidas on kasutatud meetodite ülekatmist?

• Kas ja kuidas on kasutatud dünaamilist seostamist?

Figure 1. A part of the worksheet with students' answers

Figure 1 shows a part of the worksheet with the students' answers. The topic of this workshop was superclasses and subclasses. The first question is "Whether and how the methods overriding was used?" The student answers are: "The overriding is used for methods difference and toString in classes Car, Truck and Volvo" and "Superclass has method information(), this method is overridden in subclasses". The second question is "Whether and how the dynamic binding

was used?" The students wrote: "It is used in the class BMW, which is empty and is using methods from class Car" and "There is no method information in the class Computer. The class will use the method from superclass, but there will not be the specific information".

The crucial question in organizing work in pairs is how to form pairs. One possibility is to let the students form pairs. We do so during some workshops (e.g. when the students have to present their projects). However, usually the students select their friends as peers. As they do the project with a peer selected by them (usually one and the same friend) and they can also discuss the homework with the friend before class, it would not be very beneficial to see the solution of this friend. We think the students will benefit if they can see how different people think and solve the problems. That is why we form the pairs randomly. In order to make the process more fun for the students, we use different games to form pairs, like memory game, 2-pieces puzzles, playing cards, etc.

This is our proposed scheme of the workshop, but we have different instructors guiding the workshops. Of course, different instructors conduct the workshops in a slightly different manner. However, the main components (flipped classroom, peer review and work in pairs) are presented in workshops of all instructors.

3.3 Data collection

In 2015, we decided to organize a survey to investigate what the students think about our workshops. The survey had two parts with questions. The first part was about work in pairs. It had 3 multiple-choice questions about work in pairs in general and 15 questions for answering using a 5-point Likert scale (ranging from a score 1 ("strongly disagree") to 5 ("strongly agree")) about work in pairs in our workshops. The second part of the survey concerned the flipped classroom approach. It had 4 general multiple-choice questions and 25 questions with the same Likert scale about the use of flipped classroom in our workshops. In addition, the survey had two questions with free text answer about what the students like the most or dislike the most about the workshops. A field for general comments was provided as well.

The questionnaire was administered to students during one lecture in March 2015. The students who participated in the traditional lecture or in the "intensive" group were given the questionnaire on paper. A Google form with the same questions was provided to the "nonstationarity" group and to those who missed the class. The online form was made available for a one-week period. A total of 160 students answered the survey, representing a response rate of 81% of all 198 students.

In addition, we asked the instructors of the workshops for opinion on the organization of the workshops. They had to answer ten questions about their workshops.

4 Results

Data obtained from the survey (questions with Likert scale) were analyzed using Cronbach's alpha to determine the internal consistency of the responses [8]. Cronbach's alpha on 160 responses for the questionnaire was 0.771, which suggested that the survey tool had a good level of internal consistency and reliability.

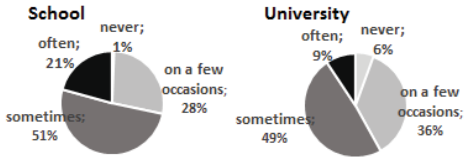


Figure 2. Student participation in work in pairs in school and in university

The students are familiar with work in pairs (Fig. 2) as quite many students indicated that they had worked in pairs often (21% in school and 9% in university) or sometimes (51% and 49%, respectively). The students seem to like rather than dislike the work in pairs (left part of Fig. 3). 49% of the students like the work in pairs, 28% selected the option "neither like nor dislike" (many of them marked in the comments that pleasantness depends on partner) and only 24% of students marked that they tend to dislike work in pairs.

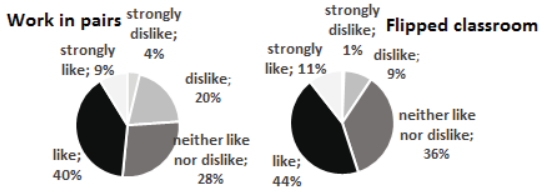


Figure 3. Pleasantness of work in pairs and flipped classroom to students

Fifteen statements from the survey about work in pairs in the workshops are shown on Figure 4. The statements were formulated using the word "usually", because pairs are formed randomly every workshop and particular peers can sometimes be unsuitable or it can happen that the work does not go well, even though usually this is not the case.

This study demonstrates that around half of learners seem to agree that work in pairs has a positive effect. The work in pairs usually goes well (statement 2) and paired students usually are suitable for collaborative work (statement 3). Half of the students think that the worksheet encourages discussion (statement 11) and two thirds of the students agreed that discussion with a peer is instructive (statement 4). Half of the students marked that work in pairs takes more time than working alone (statement 5), but the students agreed that they get more knowledge and skills thanks to working in pairs (statement 7), they get advice and explanations from the peer

(statement 8) and the outcome of the work becomes better (statement 6). The students could not indicate whether they or their peers have more knowledge and skills (statement 9) and who plays the leading role in discussion (statement 10). The responses to the question about having more time for working alone were quite varied (statement 14). The students disagreed that both peers should have separate worksheet (statement 13). Overall, the students seem rather to like reviewing the homework in pairs (statement 1).

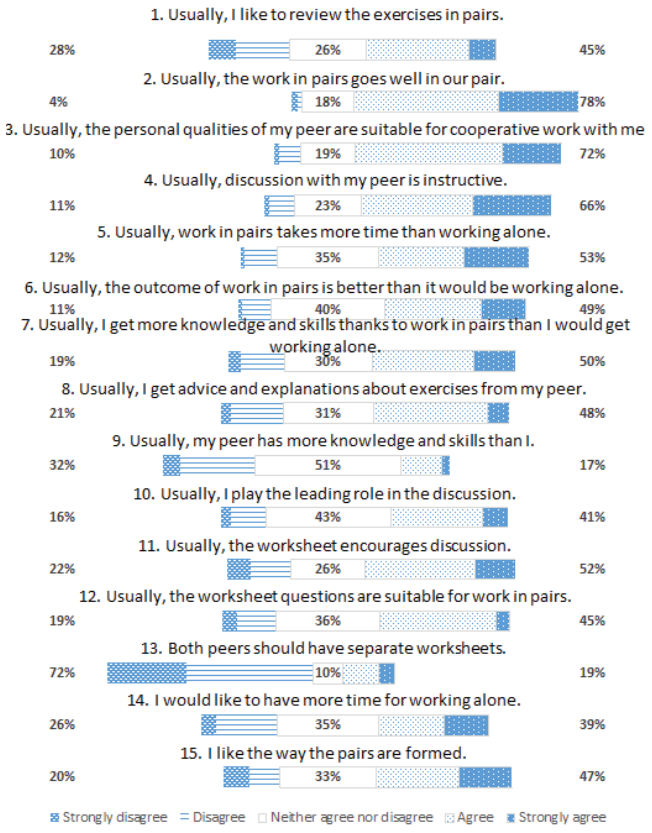


Figure 4. Likert responses to items connected to work in pairs

It seems that the flipped classroom approach is not very common in Estonian schools and the university (Fig. 5). The larger portion of students had never participated (34%-39%) or participated only on a few occasions (39-48%) in a class with the flipped classroom approach. Only 4-5 percent of the students had participated often in such classes. However, it seems that students like the flipped classroom approach (right part of Fig. 3). 55% of the students liked or strongly liked flipped classroom while only 10% did not like it.

The survey included 25 statements about the flipped classroom approach (Fig. 6 and Fig. 7). The students' attitude to flipped classroom was even more positive than to the work in pairs. Around two thirds of the students indicated that the flipped classroom approach helps them to learn this course better (statement 1) and more (statement 2) than they would learn in a traditional class. The students like to work out the material before class (statement 3). Some of them wrote in the comments that they do not necessarily like this, because it takes time, but they understand that this is very useful. Others wrote that they like to work out the material before class, because they feel more confident coming to the workshop. The students also like that, as material is known and questions emerge, they can ask them during the workshop (statement 23). They are not afraid at all to work out the material before the workshop alone without instructor (statement 9).

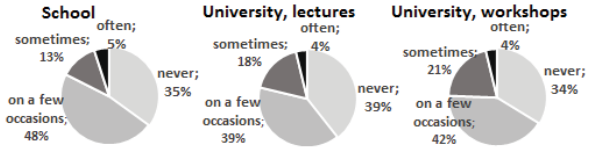


Figure 5. Student participation in flipped classroom in school and in university in lectures and in workshops

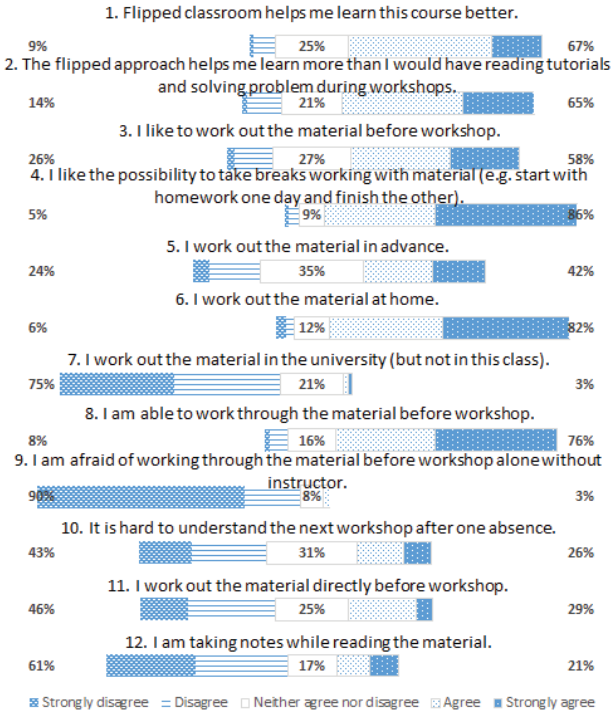


Figure 6. Likert responses to items connected to flipped classroom

The students indicated that they do homework at home (statement 6) and not in the university (statement 7). The students like the possibility to take breaks while working with the material (statement 4). However, the students do not take notes while reading the material (statement 12) (some of them commented that notes would be useful but they do not have time) and do not read several times (statement 13). The students are able to work out the material before the workshop (statement 8) and their homework is completely ready before the workshop (statement 16). The responses to the questions on working out the material in advance (statement 5) and directly before workshop (statement 11) were quite varied. There is also a large variance in the responses about

understanding the material of the next workshop after one absence (statement 10). Some students wrote in the comments that they can say nothing about this because they did not miss any workshops.

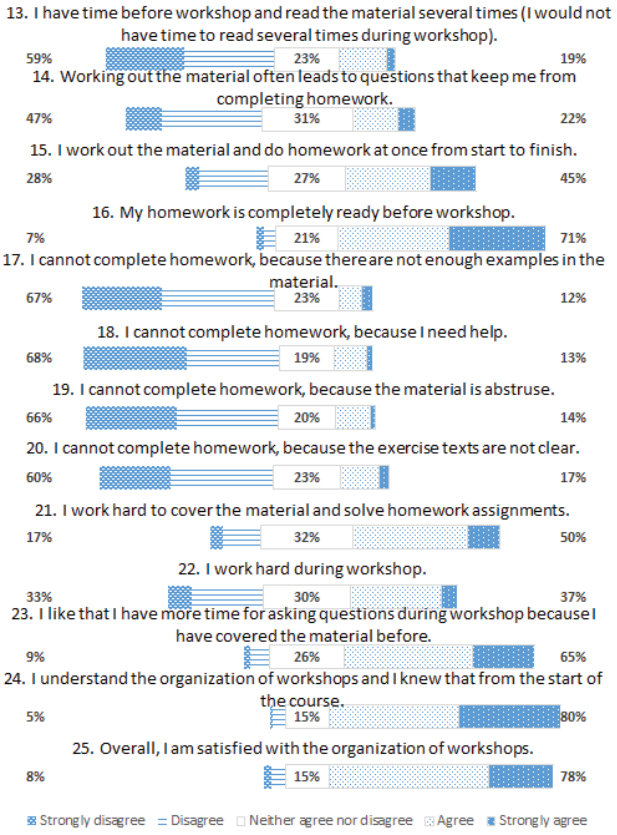


Figure 7. Likert responses to items connected to flipped classroom, part II

The material prepared for the students to work out before the workshop was rated as suitable. The material did not arouse many questions and the students could finish the homework (statement 14). The material has enough examples (statement 17) and is not abstruse (statement 19). The texts of exercises are clear enough (statement 20) and the students do not need help to complete homework (statement 18). In the comments, some students noted that if they needed help they consulted their friends or Google.

The students work harder before than during the workshop (statements 21 and 22). The students understand the organization of the workshop and they knew it from the beginning of the course (statement 24). Overall, the students seem to be quite satisfied with such organization of the workshops (statement 25). 55% of the students chose "Agree" as response to this question and 23% of the students strongly agreed with this statement.

We have seven instructors for workshops in 10 groups. The organization of the workshops was agreed before the beginning of the course. After 7 weeks, the instructors were asked for their opinion on the organization of the workshops. Six instructors indicated that they like that the students do work in pairs and fill in the worksheets, they supposed that the work in pairs makes the students work harder with homework. All instructors thought that flipped classroom is a good and reasonable approach and they liked it. The instructors liked that the students can work out the material at their own pace and are on the same level in the class. The instructors also noticed that the students are more active during the workshop. All instructors agreed that they did not want to change the flipped classroom approach to traditional class.

5 Conclusion

More and more educators start to use student-centered active learning approaches to support student learning. In this paper, we described the organization of workshops in the object-oriented programming course at the University of Tartu. We have integrated the flipped classroom approach into workshops so that the students read the prepared text material and solve necessary exercises before the workshop. During the workshop we use a collaborative approach: the students form work pairs during the workshop. We also brought peer review into the workshops. The paired students check each other's homework using the prepared worksheet.

The students were asked about their attitude to the organization of the workshops, in particular the work in pairs and the flipped classroom. The survey with questions was used as a tool. Student response to work in pairs and the flipped classroom approach was largely positive. 78% of the students were satisfied with the organization of workshops.

There were two research questions of interest. What do the students think about the work in pairs in the programming workshop? What do the students think about flipped classroom in the workshop? Half of the students think that they get more knowledge and skills thanks to the work in pairs, they get advice and explanations from their peer and the outcome of the work becomes better. Two thirds of the students think that the flipped classroom approach helps them to learn better and more than they would learn in traditional class. Since students approved the organization of workshops, we will continue with that in the coming years. The text comments provided by the students are very useful and will be taken in consideration for improving the course.

However, it should be noticed that the results of the study do not provide a comment on the success (or otherwise) of the students in learning to program. Further research could be required to investigate that. In addition, the attitude of students from different workshop groups with different instructors can be investigated. If an instructor does not like the work in pairs, it is possible that the students feel the same.

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6 References

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