Flipped Classroom Model for Advanced Networking Courses

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Abstract - Gaining competences in the field of Computer Networks is almost impossible without practical skills. Since theoretical knowledge is not enough, courses related to networking, especially advanced ones, should put emphasis on gaining practical knowledge.

Traditional classroom teaching style is not very well suited for that purpose. To try to overcome that problem, we decided to implement Flipped Classroom, with its learner-centric methodology, on some of our advanced networking courses. This approach leaves more classroom time to be dedicated to the higher level concepts, more hands-on practices and it should give students an opportunity to go with the lecture at his or hers own pace.

In this paper, we introduce a concept of Flipped Classroom, discuss its advantages and disadvantages and describe how we applied it in our courses.

Keywords - Flipped Classroom, Computer Network Education, Teaching Methods

I. INTRODUCTION

Practical skills play an important role in the field of Computer Networking. It is no wonder then, that in our classes, we try to put emphasis on hands-on labs, discussions, troubleshooting in simulated environment and practicing what was learned in theoretical part of the subjects. Even more so as the courses become more specialized and dealing with advanced networking topics. Yet, it often happens that the students just do not have enough class time to do some more challenging tasks in the scope of the lecture. They often cannot go deep into a particular subject they are interested in or cannot have enough hands-on practice to become more confident in their work.

On the other end of the problem scale are theoretical lectures. Presenting a lecture in a traditional way has become boring and many students find it waste of time, since they can find this information by themselves. Most of them are generations who grew up surrounded by Internet and smartphones and are used to finding relevant information online when they need it. Lecturing in the field of computer networking is even more challenging because it contains a lot of details, numerous protocols and great diversity of subtopics, making it rather abstract to students. This leads to students losing their focus and switching it to their smartphones or laptops. Research in literature shows that the same problem exists on other universities [1]. Another problem is that the pre-existing knowledge of the students is often not unified. Moreover, with topics like IoT, Cloud computing and Virtualization, which we need to incorporate into curriculum to stay up-to-date, there is not much time to cover everything in depth.

For all of those reasons, we gradually switched over the recent years towards blended learning methodologies and decided to implement Flipped Classroom model. For the reasons discussed later in this paper, we decided to try it just on our advanced networking courses and not the basic ones.

The rest of the paper is organized as follows: Section II describes the main method we used, Flipped Classroom. Section III covers implementation of the model to our courses, in Section IV we give the results and Section V brings Conclusion and our ideas for future work.

II. FLIPPED CLASSROOM MODEL

The idea behind Flipped Classroom (FC) is to reverse order in which the new lecture with its contents, related assignments and homework is delivered to the students.

In the traditional classroom, teacher has the active role and the students take the passive role. Usually, they sit and listen to a lecture without too many interruptions and at the pace set by the teacher. In addition, the lecture usually covers basic concepts, while the more complex ones are often left to be tackled by students during their homework assignments. In the Flipped Classroom model, this approach is “flipped” – the students cover basic lecture material by themselves before class and after that, in the classroom with a teacher as a mentor, they do what was in a traditional classroom homework assignments.

This model seemed very suitable for networking courses, where the lectures can be partitioned into more narrow topics and therefore presented as a greater number of shorter video lectures. Even if left as a long video lecture, depending on the student’s needs and pre-existing knowledge on the topic, a student is able to pause, rewind or go through video at a faster speed. Practical work and more complex assignments play a great role in achieving learning objectives and have much more impact if conducted with the presence of a teacher or done in a
group. With the students who have more advanced knowledge than their peers, teacher is able to do even more complex assignments or those students are able to improve a different set of skills like leadership, teamwork or expressing themselves.

A. Related work

The idea of inverted classroom dates back from 2000 [2], but Flipped Classroom or Flipped Learning approach became popular around 2012 (Figure 1) with the work of Bergmann and Sams [3]. We could argue that the main reason for much wider adoption of this model in that period is their timing, which overlapped with the everyday availability of new technologies such as smartphones and anytime and anywhere high-speed Internet connectivity, which, in turn, enabled content such as video lectures to be easy to access.

![Figure 1. Google search popularity of the term “Flipped Classroom” from 2008-present](image)

With the rise of FC implementation across the globe and into higher education institutions such as universities, came the rise of number of research papers (Figure 2) with different results regarding the success of the FC model. A review paper [4] shows that majority of studies claim students greatly benefit from FC and outperform the traditional classroom model, but there are also reports that claim that students might not be ready for or benefit from this type of learning [5].

![Figure 2. Number of published papers with keywords related to FC through the years](image)

In this work, we will focus on the ones directly related to the topics in the field of computer networking; detailed analyzing other results is outside of scope of this work.

Although there is not many empirical studies related to computer networking, those that exist show that implementing FC was a success. For example, Tian et al. [6] have found that experimental FC group has achieved higher average score on quizzes by 4% and they mostly performed better on synthesized questions, which showed the ability to put learned knowledge to practice. Moreover, the students themselves reported improved abilities to resolving a new problem, to expressing themselves and to cooperate within a group.

Research conducted within the Computer Network course for the final-year engineering students [7], shows that significant number of students in experimental group reached apply level of objectives of Bloom’s Taxonomy [8], compared to the control group where students mostly reached only remember level. Majority of students in the same study reported enjoying the FC’s activities.

Another paper [9] states that the results gathered from comparison of two groups of students, one using FC, the other using traditional classroom, show that the FC is better in the overall achievement with a difference of approximately 20%.

The rest of the literature regarding the courses of Computer Networking [1],[10],[11] deals mostly with implementing FC model into existing course, but without empirical data showing either success or failure.

B. Advantages and Disadvantages of Flipped Classroom Model

There are numerous benefits of FC model which some of the related works summarized [7], [10] and we mention here the ones relevant to our study:

- Students move at their own pace
- More face-to-face time with the students brings more interaction and means to clarify difficulties
- Teachers can more easily customize curriculum
- Classroom time can be used more effectively and creatively
- Use of technology is flexible and appropriate in today’s environment
- Students share knowledge in class, which leads to reinforcement of what they had learned
- Short video lessons more interesting for students than long lessons

Some disadvantages of the FC model, among others include [5], [7], [10],:

- Students may come unprepared for the class and are therefore unable to actively participate. Usually it is because FC model puts them in an active-learner role, which requires more self-control and independent learning.
- The prepared material, such as video lectures and readings, must be carefully prepared to
be interesting and engaging. This requires extra time and effort on teacher’s part.

- It can be difficult to implement FC into university’s standards that belong to governmental program
- Size of the class; it is much harder to implement FC into an obligatory course taken by hundreds of students than in a small course
- Different personalities among students make it impossible to satisfy everyone’s needs, e.g. shy students can resent presenting results publicly

Although it is not a general disadvantage, we would like to present another potential problem with implementing a FC model and that is age of the students. Research shows [5] that junior classes are more ready than freshmen to learn by Flipped Classroom model. Readiness to participate and accept this method of learning plays a significant role in overall achievement results. This finding, together with the size of the class is the main reason we decided to implement Flipping Classroom only to our advanced networking courses.

C. Flipped Classroom Teaching Design

There is no one design that fits all courses and classes, but most of the designs includes the following:

- A recorded video lecture, accompanied by PPT slides or lecture notes prepared by the teacher
- In-class activity, usually practical, Q&A sessions
- Group activity and group assessment
- Quizzes

It has also been experimentally confirmed at Zagreb University of Applied Sciences that well-formed interactive multimedia design (including PowerPoint presentation, FC video content, etc.), give better results than the traditional face-to-face teaching (F2F). This is proven especially if using Merrill’s basic principles of instructional design with cognitive theories of multimedia learning and Mayer’s principles of multimedia learning [12].

III. IMPLEMENTATION OF FLIPPED CLASSROOM

Our advanced networking courses are based on Cisco Certified Network Associate (CCNA) Routing and Switching education version 6.0. It consist of four modules which are separated in four courses accordingly. These courses are fully integrated in classes at master’s degree study, but several courses from bachelor’s degree study also use these materials in their classes. Since networking courses put great importance on practical skills, Cisco Networking Academy has prepared variety of materials for their educations. All materials are located on learning management system and all Cisco academies and their instructors have central place for educations where they can improve and personalize materials [13]. Also, they can import some chapters and modules from other educations and by that extend original course with additional curriculum. These materials consist of Instructor PTT slides, interactive online quizzes, videos, online simulators, networking simulation software Cisco Packet Tracer with dozens of exercises, as well as prepared hand-on labs, which are often solved in pairs or groups with following discussion.

Our implementation of Flipped Classroom model utilizes those materials, since they cover almost every important design feature mentioned in Section II.C. What we were lacking were video lectures for students to prepare them for the class activities.

From year 2017, we have decided to record all lectures within these four modules and we came up with total of 49.5 hours of video recordings. Courses started in February 2017 and finished in January 2018. Each course has been eight weeks long and classes were held once per week in groups of 12 students, each in various durations, depending on length of chapters and their complexity. Given that, we were spending roughly 50 hours on lectures per group each year. Those hours could have been better used for practical exercises in lab environment.

As videos were uploaded on YouTube channel [14] several weeks after recording due to editing, in that academic year these recordings were used just for re-watching missed or misunderstood chapters and as a tool for studying for exams. As part of Flipped Classroom model for theoretical preparation for practical exercises, recordings were ready to be used only the following year.

Since networking courses demands detailed research of some topics, we decided to keep traditional lectures for first module (Introduction to Networks) because it is the most extensive one and it has to prepare all master-level students with different levels of foreknowledge for complete networking education. We decided the same on our bachelor-level networking course, but for the reasons mentioned earlier in this work – we argue that the age of the students is relevant factor in their readiness to accept FC style of learning and the introductory networking course has over one hundred students, which makes it hard to implement as FC. Other three master-level courses and one advanced bachelor-level networking course did not have full-length traditional lectures but only brief theoretical introduction on subject for practical exercises that followed. At the beginning of the second course, students were able to watch videos as a preparation for upcoming exercises.

IV. RESULTS AND DISCUSSION

At the end of fourth and last course for master-level students, we conducted a small survey and asked students their opinions on video recording. We also reviewed the statistics of video ratings.

A. Survey results and video ratings

Summary of YouTube statistics from January 2019 is shown in Table I.
It can be seen that average length of a video is roughly one hour, but average watch time is just 7:52 minutes. Video viewing trend (Figure 3) showed that the students’ motivation for watching videos rapidly drops after a few first lessons. Only anomaly is in first module with eighth lesson recording 333 views.

When asked on preferred learning method, students replied as shown in Figure 4.

As students said in survey, they “would be more motivated to use videos if they were given an award in form of bonus points”. In addition, some of them noted that they “would be more motivated to watch videos if lecturer would not hold short theoretical introduction to practical exercise”. Student opinion is shown in Figure 5.

Another significant statistic are students’ final grades shown in Figure 6. It shows grades of one generation of students who were studying by the FC model.

B. Discussion of the results
Following end of the first module, students have noticed that short theoretical introduction at the beginning of the practical labs was mostly enough for them to successfully solve an assignment with usage of class based materials. One of consequences was that usage of video lessons started to decline as course was reaching its end as it is shown in Figure 3.

The anomaly in the statistics is expected because eight lesson is subnetting which can be tricky for some students
and it requires more practice than other topics on Introduction to Networks course.

Although viewing trend and survey results state that the majority of students did not watch videos, teachers report that the students mostly came to the classes well prepared, probably through other type of materials, e.g. books, other YouTube videos, lecture notes, Cisco Networking Academy course materials, and were able to do the assignments. Final grades, achieved through the exams, also show that majority of students reached learning objectives. This shows us that implementing Flipped Classroom was still a success.

In the future, we plan to make some improvements, such as cut video lessons in smaller chunks and introduce a small quiz at the beginning of the hands-on labs for extra points. At this time, removing short introduction at the beginning of the lab we find counterproductive.

V. CONCLUSION

Advanced courses in computer networking are highly practical courses where hands-on experience and collaborative work are of the essence. It is also a rapidly evolving field with emerging new technologies that students need to be acquainted to be prepared for the job market.

Flipped Classroom model of teaching, with the basic lecture left to be covered by students at home before the class, leaves extra hours of that precious face-to-face time for hands-on labs and discussion of higher-level concepts, as well as introducing new and interested topics. Research shows that implementing FC model was usually very successful.

Our own experiences shows us, although with a wide room for improvement, that Flipped Classroom is indeed suitable for advanced courses dealing with networking and we will continue with its implementation.

REFERENCES