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Lappeenranta University of Technology  
School of Industrial Engineering and Management  
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Master's Thesis

**Flipped classroom technology from teachers' perspective:  
implementation experience, barriers and perspectives**

Iuliia Shnai

Supervisor: Prof. Leonid Chechurin

## ABSTRACT

**Author:** Shnai Iuliia

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Blended learning approaches rise their popularity, however not all professors apply them and find them useful and appropriate. This research focuses on study of flipped classroom arrangement and effectiveness of this concept implementation.

The Master's Thesis explores impact of flipped classroom implementation on resource savings for professors. The research is based on the literature review of different education arrangements and results of their implementation, on the survey conducted among professors from different Universities and on two experiments of flipped classroom implementation.

The results reveal advantages and disadvantages of the concept, professors' attitude to it and possibility to future research and practice in this field

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Shnai Iuliia

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**LIST OF ABBREVIATIONS**

**ANOVA** -Analysis of Variance

**ASR** - Automated Speech Recognition systems

**CMS** - Course Management System

**CDS** - Course Development System

**LCS** - Lecture Capture System

**MIT** - Massachusetts Institute of Technology

**MOOCs** - Massive Open Online Courses

**OCW** - Open Courseware

**OER** - Open Education Resources

**VLE** -Virtual Learning Environment

**VMS** -Video Management

## 1. Introduction

This report represents the research in the pedagogical and technological field. Two topics are combined and cover innovative methods and technological tools in education arrangement. Widely reputed the potential of increase the effectiveness of lectures and whole courses, which can be realised by implementating new approaches. Alternative to the traditional form, blended learning becomes more popular in last years. Blended learning presents mix of traditional and new methods, concepts, and technologies. Open education, on-line, distance learning, active approach, learning by video, mobile use learning, flipped classroom, adaptive learning can be roughly separated from others as groups. Mergers of methods or concepts also occur in a while. Classification of blended learning methods alongside with historical time line of facts and trends are created by this work.

Mainly, the research is focused on examination of one blended concept - flipped classroom. Flipped classroom is a reversed approach, where already used components are arranged in a different way. Variety of blended forms is described in this thesis to explore more about inverting the classroom, because it presents combination of previous methods. In a huge number of articles inverted classroom implementation brings positive results and the efficiency of flipping is proved. It raises its popularity, but the scale of possible use of flipped classroom and other methods and the whole impact in a long – term perspective are still not clear. In this thesis special attention is drawn to dealing with its resource-based efficiency. The research tends to study professors understanding and perception of the concept, attitude and possible application. Fresh outlook on flipped classroom's study in this work reveals advantages and disadvantages of flipping for all participants, not only students. Apparently, most authors frame their research with examining impact only on students. On the contrary, the main framework of this study exploring the effect on the three main stakeholders of the concept: students, professors, university. The value of flipped classroom method for the professors and consequently university is distinguished. This value is expressed in amount of avoided resources: time, space, and efforts. The resource effectiveness of free time, space for the classes, efforts of professors spent on a class and preparation to it and following that financial expenses, which university spends for that. In this research the effectiveness is counted through the

deep analysis of the literature, questionnaire and practical implementation of the concept (experiment).

Finally, it is supposed, that cut in the resources can prove the importance and necessity of flipped classrooms implementation in Lappeenranta University of Technology (LUT) and in Peter the Great Saint-Petersburg Polytechnic University (SPbPU) allowing building modified business model for the partially shifted educational arrangement.

This work is relevant for those who want to study more about inverted classroom and find answers on the already existing gaps in the literature. Analysis of the articles helps to clarify the sharpest questions. Special attraction it represents for everyone who is interested in education, its technologies, tendencies that form new information era and all the impact of it. It is clear that, the relevance of the topic is not limited by specialists in the field.

The research is relevant, because it moves toward extending understanding in education field, which brings social value and economic prosperity for the country (Orlič, 2014). Changes in our life cause fluctuations in the standard way of education. Nowadays, life is penetrated with mobility, interactivity, visualization, and technology. Educators and universities thinking about adaptation of learning to the new generation, to Millennials that have different expectations, styles and information consumption from previous generation of students (Skiba, 2006). It is still not obvious how to satisfy all the needs, - Muñoz (2013) argues, however it definitely requires more researches. Hester Tinti-Kane, Vice President of Marketing and Social Media Strategy, Pearson said: "The more we know about effective uses of technologies for teaching and learning, the faster we can adopt these new practices, facilitate their proliferation across higher education, and increase student success" (Seaman Tinti-Kane, 2013).

## 2. Research

### 2.1. Research topic, framework, objectives and questions

Research topic meets the currents of time and seems feasible. It is supported by accessibility of information for the topic, which is shared openly, and technological tools, which can be tested for free. This research presents personal interest for me as a person, who has gained some work experience already in the field and would like to keep on in this area. This research is a logic continuation of the field work conducted in my Bachelor Degree study, in my Master Thesis and during my research assistance position with Prof. Leonid Chechurin.

Progress, with its constant improvements, forces increasing the efficiency and reducing expenses of education. The main problem is to cut resources for the education without loss of quality. It means raising the efficiency of education without quality reduction. In this study the resource based analysis is conducted.

Three main aims are distinguished within this thesis:

1. To categorize and describe variety of blended learning technologies and modern approaches in education
2. To review the applicability of flipped classroom and deduce the recommendations for its implementation
3. To define change in resource effectiveness (for the professors and university) in inverted classroom implementation

**The main research question is:** «Does flipped classroom approach lead to resources savings and how it can be implemented properly? »

**Sub-question 1.** What is the percentage of professors who can apply the concept?

The possibility is studied regarding to the professors' desire and their courses conformity.

**Sub-question 2** What are the recommendations for inverted classroom implementation?

The advices are gathered according to the professors' opinions, also the number of flipped classroom researchers are analyzed and the gaps are clarified.

**Sub-question 3** Are there resource savings after implementation of inverted classroom without loss in quality?

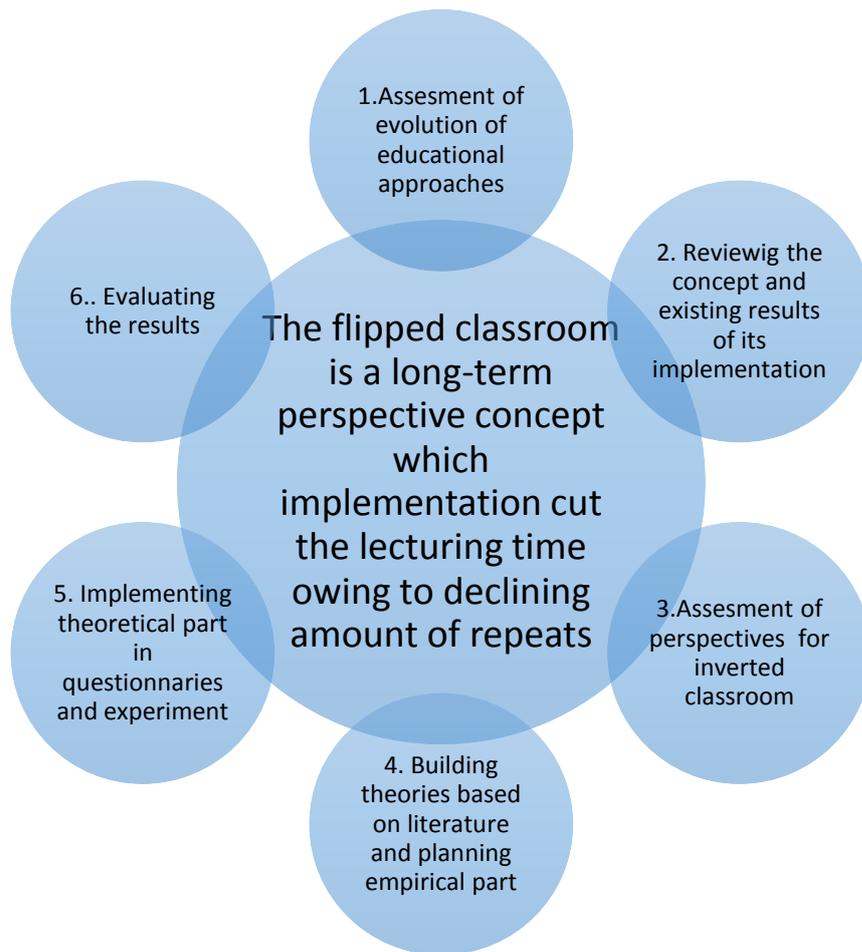
**Sub-question 4** What is the impact of different tools and methods of implementation?

It is important to study influence of different technological tools, find difference between them, and choose the most appropriate and reliable option.

Once we give answers for the all sub-questions, research objectives are fulfilled and the conclusion can be formulated.

**The hypothesis for this research was formed based on the literature review:** “The flipped classroom is a long-term perspective concept, which implementation cut the lecturing time owing to declining amount of repeats.”

Theoretical framework for this thesis allows checking the main hypothesis. It has 5 main contributions. First three parts are assessment of the literature, traditional and blended methods including the flipped classroom, popularity of it and existing results. Next step, which compounds the hypothesis is gathering results from literature and planning empirical research. After that, the empirical study is conducted. Finally, all gathered data is evaluated and it proves or disapproves hypothesis (Figure 1). Environmental framework for this study is a higher education establishment. Universities limit research; however schools also widely apply the flipped classroom concept.



**Figure 1. Theoretical framework**

## 2.2. Content, issues and structure

The literature review covers number of issues aiming to simplify the inverted classroom implementation.

### **Issues covered in Literature review:**

- 1) What results the previous researches bring?
- 2) Do flipped classroom improvements just result in activation of the class?
- 3) Is it effective to mix flipped classroom with adaptive?
- 4) Is the concept expected to be more popular in the future or to remain a short-term trend in education?
- 5) What is the technological impact on inverted approach?

### Issues covered in the Empirical part:

Issues, which were not clarified in the literature, were clarified in the empirical part by including in questionnaire or experiment.

- 1) What are the components and barriers for flipped classroom implementation?
- 2) What are the components and barriers for technology use?
- 3) Do professors wish to apply inverted classroom?
- 4) Are the professors' courses suitable for inverted classroom?

### Structure

The structure can be presented in a process way, in which each chapter will have its input and output. Overall, thesis consists of 7 main parts. The introduction describes the background for the topic. Research section points out the objectives of the study and gives the picture about methodology by giving plan and framework for the study. Research part in the thesis is shaped after preparing the initial literature review, where observation analysis for the topic is made, main questions and gaps are formulated. Next step is to deepen into the literature. In the fourth part, the plan for empirical study is constructed, aiming to answer research question and cover other issues. In the part with results, the data from the questionnaire and experiments is gathered and assessed. After that the results are discussed regarding to the aims, issues and research questions. Finally, the conclusion outlines the achievement of our goals.

**Table 1. Structure of the thesis**

<b>Input</b>	<b>Part</b>	<b>Output</b>
Introduction to the topic and to the thesis	1-Introduction	Aims of the research, research question, content, structure, gaps
Information about possible ways of conducting the	2-Research	Steps of the research and plan for each step.

research		
Literature for the topic	3- Literature review	Learning trends through historical periods. Validation of significance of the research question and aims
Data from the questionnaire and experiment	4-Data analysis and collection	Processed data
Data from the quantitative analysis	5-Results and findings	Assessment of the data
Results and findings	6-Discussion	Answering research questions and recommendations
Discussed results	7-Conclusion	Finalizing about success of the research, future perspectives and advices

### 2.3. Research design

Thesis research compounds in the systematic way to achieve main aims and to check the hypotheses. The data gathered by three main ways: literature review, questionnaire and experiments.

#### **Design**

This research has two main strategies: survey and experiment. The survey allows collecting quantitative data from professors and analysing it quantitatively. And experiment allows getting the missing data, and finally showing how the flipped classroom implementation influences on resource effectiveness of education arrangement. For this exact study, it will be numbers, which can be gathered just by practical use of the concept. Mainly it is going to be exploratory research as far as it

includes literature review and expert's questionnaires and explanatory research, because it explains the attitude between main variables. The mixed method of data collection and analysis assigned as the most appropriate. The study of flipped classroom implementation for particular class should be estimated in a long-term perspective.

### **Credibility of findings**

Reliability of findings is supported by the professionalism of the professors and their personal interest in the concept and in the research, which can bring values for the professors. The data is analysed using SPSS, which allows eliminating errors and bias. The validity of research is maintained by the building clear logic for the questionnaires and experiment. Any extraneous factors and previous studies can be dismissed as far as there are not so much of them directed to the professors. The disposition toward getting positive results, which means finding the effectiveness of the inverted classroom implementation, is tried to be avoided. And the results of the study are not generalizable to any class, any professor and any subject, and are only to be attributed to the exact education arrangements. Still, logic leaps and personal factor's impacts impossible to eradicate fully

### **Limitations**

Limitations for the research are small sample size and one field sample. Mainly, the professors, who take part in the research from one department in LUT and one in SPbPU, both from the correlated departments. So, the study covers two Universities in two different countries. One more limitation is that the developer of the flipped videos in the first experiment and of the active system in the second experiment is one person with the thesis writer. Bias in, description of the systems and interpreting the results is tried to be avoided.

## **2.4. Tactics**

### **Data collection**

The data in this study was collected by two main ways questionnaire and experiment. Questionnaire was provided for 50 professors from different Universities. Both of the experiments have their own original design and conducted with Professor Leonid Chechurin.

### **Sample**

As far as this study aims to get the attitude and resource effectiveness for the flipped classroom implementation for other stakeholders instead of students, the choice of sample was between professors, heads of university and developers. Professors were assigned according to the purposive non-probability sampling. Professors, who straight apply and develop the courses by themselves, form the representative group.

Professors from two different universities in two different countries Russia and Finland are included in the sample for the questionnaire. Sample is formed according to my studies and possible access to the professors. It includes in SPbPU studies on Innovation Technologies and LUT on Global Management and Innovation Technologies (GMIT). It is supposed, that acquaintance with the professors increase the response rate of sample. Moreover, the main field of both of these departments is innovation technologies and it means that they are straight connected to the technologies. So it can be assumed, that the specifics of the field, leads to necessity of learning material upgrade. Constant redesign of the courses occurs, alongside with the rise of new methods of teaching and developing information about the topic. Probably, professors are more used to work with technologies and innovation methods as far as they teach innovations. Thus, the interest to and potential for implementation of innovative flipped classroom method in education is higher. These two departments in different Universities cooperate with each other and have a Double Degree program, in which I took part.

The professors who took part in the research had completely different experience in the field. Some people in the sample could not take part in the research as soon as they did not have courses. Therefore their answers are eliminated from response rate. Initial sample size is 50 people. The statistics is gathered from 25 respondents, who answered the questions.

The two levels of research mean that two main samples will be assumed. The sample for

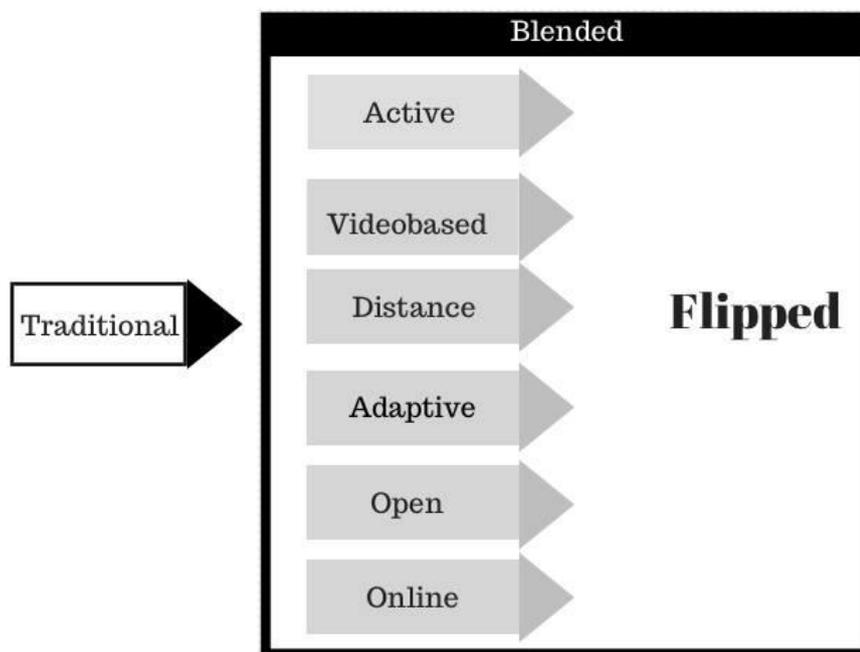
the second part of the research comes from the survey results. Second sample does not contain the professors who have no desire to apply concept. Also they are not included if the structure and course arrangement don't allow, for example if the rate of the upgrade is really high. After that the professors answer personally about their interest to fragment their course.

### **Data analysis**

The data from questionnaires is analysed by using Statistical Package for the Social Sciences (SPSS). The Factor analysis, Anova and correlations analysis are made. Factor analysis aimed to reveal the most significant correlations in a high number of variables Anova is used to compare the difference of means for different groups of professors and to reveal the influence of amount of lectures on used approach.

### 3. Literature review

Conception for the literature review part is historical consequence of birth and growth of different concepts from traditional to blended. Finalized by the “Frankenstein” approach of flipping. The Figure 2 shows traditional and transformed from it blended approaches. Flipped type described as a combination of other blended types. Main focus is made on technology use, seeking to give categorization for different representatives. Each trend description shaped by general information, role in education, concrete in lecturing, and connection with other trends, results and covered issues. The deductive approach of critical review forms the framework from literature, which will be tested further. A number of questions without the answer are revealed in this section. Answer on them helps to guide in the field of study.



**Figure 2. Traditional and Blended approaches**

#### 3.1. Historical trends in education

Education reflects trends and approaches regarding to the time-period. Each of them

transforms education system temporarily or in the long-term perspective. Thus, industrial era characteristics constructed used-widely used traditional approach. Digital era forms the blended culture of knowledge creation and learning processes (Panto and Comas-Quinn, 2013). In 80's evolution, as a shift from traditional approach to blended, goes with the rise of computerization, economy of information, technology use and conceptual understanding of ability of improvements or changes in the field. Transformation has still passed. Varieties of new forms and modifications have born. They can be grouped in biggest clusters, which represent the certain concepts: openness, distance, activity, adaptation, flipping, and virtuality.

At the beginning, education was transformed by technology implementation: *active technologies, audio, video content, and presentations*. Launch of inexpensive and available for common user presentation packages first were made by Hewlett Packard in 1979. After that, the concept of openness became real in all different fields, and then knowledge was transferred cross the national borders. The boom came with Massive Open Online Course (MOOCs) in 2002 and with variety of open platforms. The source, which made it possible, was Internet, which was introduced to the public use approximately in the late 1980s. Internet became a medium of e-learning for *online, distant and open education platforms*. *The concept of flipped classroom* mainly flourished because of change in student's consumption of distance learning, including open courses. Normally, in most schools and universities distance courses or videos were developed for online learners or for students who missed the classes. Surprisingly, professors realized that students who visited classes also watch the materials and deepen into it (Tuker, 2012). At the same time open education came to the flipped classroom by transferring the lecture hall experience to the laptop by packing concentrated information in short videos and leave only activities for the class (Bogost, 2013). Nowadays a lot of Universities prepare courses in MOOCS and use them for flipping their real-classes. Thus, students who attend classes watch the same videos as students, who take the courses virtually. One more *trend is adaptive education*. Adaptivity is the most desirable aspect started from the 21st century, which apply interactive tools for teaching according to the personal needs. Adaptivity concept also can be mixed with the flipped one. For example, by adding more learner-centered tools, which simplify learning process.

### 3.2. Traditional education

Professor Cathy Davidson from Duke University proved that traditional education in its core deliver disciplined way of learning specified by quiet sitting, single problem solving and thinking processes (Bogost, 2013). Studying alone in these conditions does not mean personalization and adaptation of education, rather a lack of communication between peers and professor. Traditional lecture tend to be a teacher-centered method, than student.

Traditional education can be performed by its unit – lecture, which has its own form and characteristics. Philip Boffey (1962) from Harvard University wrote about lecture as “a chief method of teaching”, even since 1962 it has had a huge number of drawbacks. Lecture is still the most widespread form of information presenting and the most popular way of education in the universities and at that time it had even greater gaps and disadvantages. Insufficiency to achieve effective results in the class performance in digital era is described in the article “10 big problems with the lecture” (OnlineUniversities, 2011). As a consequence of these negative facts the effectiveness, attitude and other main measures are low.

Lecture is a passive and not dynamic way of teaching. Definitely it depends on a lecturer, however monotonous style of declamation fully extirpates all attention, involvement and interest to study (Bergmann, 2012). Subsequently, students feel boring and do not get new experience, it is fast and the material is easy and quickly forgotten. Student attention after 10 minutes of an unvarying narration significantly declines (Hartley, 1967), (MacManaway, 1970). Average span is no more than 20 minutes from the beginning (Stuart, 1978), (Richardson, 2010). Also this approach presents just theoretical knowledge without engaging different learning styles. Pure listening makes listeners to remember just 5% of given information. As the consequence, listeners don't develop existing skills or get new knowledge. As soon a teacher is a main authority, the information given can be biased. Students cannot get other opinions than professors' one and for the reason of absence of the communication and instant feedback, the information cannot be discussed (OnlineUniversities, 2011).

### 3.3. Blended learning

Variety of mixed learning approaches formed by three main impacts: mixing by implementing new concept (conceptually), by applying technologies (technologically), and by using Internet.

Conceptually hybrid education is a learner-centered, where student is a moderator of the class (Job, 2015). Bogost stated (2013) «It is process-oriented, distributed, and exploratory method of learning». Majority of researches of different mixed styles give positive results of improvement. That's why these outcomes show benefits of learner-centered methods over the teacher-centered (Ankeny, 2014). It still has a number of gaps, misconceptions, low satisfaction and requires new experience, a lot effort and familiarizing with new technologies (Parslow, 2012).

Technologically, a huge number of tools, including Internet transformed traditional education; however its implementation must be reasonable and appropriate. Practically, all blended methods give more motivation, participation, activation and adaptation to students. The motivation can be divided in two types, inner caused and caused by external sources. The motivation created by using of technologies in education is external, that is why the long-term results not always positive, and can generate a boomerang effect. The covering pressure from external technological motivation leads to infantilism, concerning self-study caused by desire. The full shifts to student-centered approach leads to decline of the intrinsic motivation and creativity process (Hennessey, 2015). Definitely, not all technologies and innovation cause it, some instruments, like open education maintain inner incentives. Open education launches a self-study mechanism. Adaptive technologies are opposite to it, suppress all self-incentives. It can be concluded, that the balance in introduction technologies and mixing learning should be dosed.

Overall, blended learning study can bring positive results for education and show ways for the future development and researches. For example, Prober and Khan after flipping came up with ideas of reimagining the materials for study by doing it in collaboration with other universities (Khan, 2013).

### 3.4. Active learning

Active learning means using active methods and technologies and environment for eliminating passivity of the lecture and breaking the monotony. Three main components of successful active learning class can be defined: appropriate technologies; appropriate implementation and appropriate style of teaching using technologies.

The variety of technologies expands and now professor can choose the one which will activate the class. The main technologies for activation of communication are: feedback systems, test systems, quizzes and visualization technologies (video-audio content, presentations). The key element of active learning is interaction. Interactive learning is an active learning technique, which combine methods, approaches, technologies for communication between professor and student (Rumina, 2015).

The communication is successfully established only if the feedback from students is strongly appeared. In other cases, when the interests of students are not clear, an action of the professor without intent is nothing, just occupation of the time. (Job, 2015). Hence, two types of educators with different styles of teaching can be distinguished, first who are concerned about what students are interested in and who are interested in student speaking and involving in the process, and second who want to achieve the goals for the class and fit in the curricular (Job, 2015). The first type builds his/her class in a form of the learner-centered method of active learning directed to the student needs and interests. The student becomes a moderator and facilitator and manipulates the objects. The second one is one-main authority in class and feedback is just an answer to the professor's questions. Such one-sided communication creates lack of correspondence of materials, which are given, and understanding or knowledge for students. In that way, the communication is biased by professor's authority and not enough time is spent on individual discussion with students.

Regarding to interactive systems, there are two main types, which are used in two situations. The first one represents the system, which allows students to ask questions or to take notes at any time. The beneficial system allows student to take notes, which are

instantly performed on the presentation screen above other windows, without interrupting the professor. Second type is a system, which allows student just to answer concrete professor's questions, can be supportive. Shifting to the active learning is still challengeable for some fields. Principal concern is about activating the engineering field courses (Gillet, 2005).

As soon as active classroom is a part of flipped one, the plan for the latter implementation should correlate with already studied effectiveness of different active technologies in different fields. The **gap** is which technologies and in which field can be applied in more effective way?

### 3.5. Distance learning

Distance learning is arrangement of the educating process using distant sources of information. Distance education erases the distinction between different countries, universities, languages and cultures and quite to the contrary increase communication, mutual understanding and cooperation. It came to our life starting from development of different mediums. The text, audio, video content was recorded first on the floppy disk, disk, flash drive and then shared. Now all the information is being shared through the Internet. Two main types of distance education can be distinguished: closed and open. The difference between them in different terms of access, however the resources can be the same: courses, courseware and platforms. Closed one has limited or chargeable access for its users. For example, distance courses which go alongside with one's real courses, distance education for a fee in detached, inaccessible or just foreign university. As far as the concept of open education has been gaining more popularity and value, further it is presented in detail.

### 3.6. Open education

In the last 10-15 years the concepts of openness, sharing and accessibility penetrated in

all spheres of our life. Openness is a concept, which based on transparency and free access to information, including national collaboration and cooperation (Peters, 2014). Open education contains practices and knowledge from different educational organizations or people, which spread it with a free access. The information, which is openly shared can be reused, modified and improved. Socially openness is a new business model for innovation launch. Practically all open systems usually decentralized and available globally (Peters, 2014).

The push to development of open education and open education resources (OER) was first initiated in 1990's by the Massachusetts Institute of Technology (MIT). In 2002 MIT launched first open courseware (OCW) by uploading 50 courses on the open platform (Panto, 2013). After a year this university presented more than 500 courses. Following it, other Universities and educational organizations started moving in the direction of open education and build new business models. The number of Open Education Resources (OER) and open universities rapidly grow (Panto, 2013). Open universities was called by a former president of MIT in 2006 as “meta-university—a transcendent, accessible, empowering, dynamic, communally constructed framework of open materials and platforms on which much of higher education worldwide can be constructed or enhanced” (Baron, 2015). MOOCs (Massive Open Online Courses) were presented as start-up platforms which gather online courses for unlimited use (Panto, 2013) from universities all over the world. The universities share their courses, classes in different forms and students can learn through the emerged platforms or university website (Panto, 2013).

Nowadays, open education is conveyed by three approaches: sharing around the world knowledge and learning materials, cooperative programs and standardization of the processes (Baron, 2015). Knowledge and materials are delivered by variety of e-learning resources. In free access, they can be evaluated and improved. In united programs Universities develop content, which contains foreign and new practices and organizes study abroad programs for exchange. Standardization of the processes helps students move/shift easily from one higher education system to another and professionals to try their skills in different countries and earn new experience (Baron, 2015). Nowadays the Bologna Process performs this function.

The biggest interest for the education presents Open Education Resources (OERs). Roughly, they can be divided into three main groups: 1) *sources of information* (full package courses, not-full package courses (course materials and modules), texts, videos) 2) *course wares and course management systems* and 3) *platforms and repositories which gather or maintain them*. Also some popular social networks apply this concept. Even Facebook can be used as an educational open source if address its technical and communication resources to the educational direction (Buragga, 2013).

A full-package course is a source where we can find whole courses and on some of them combine the given elements for professor's course. These courses can be published on the university website or on the adapted platform for different courses from universities and professors all over the world. MOOCS are this type of courses. Course materials, modules are parts of full courses. They can be gathered on other platforms than full-package courses. Video resources gathered on the platforms with the content in the form of videos from different universities in one website. Textbooks, books and articles presented in archives and databases. Repositories gather different materials, which donated or contributed by the universities and people and represent the databases or archives. Archives or databases collect freely accessed textbooks. Interesting input comes from open platforms where you can find or upload software which is distributed openly or with a flexible license, can be used by others, improved or adapted and publish your own programs (Baron, 2015). For instance, Sourceforge.

Open sources exist among CMS course management systems (CMS), but not all of them have a free access. Programs with advanced technologies and with high level of adaptation are still chargeable. There are 3 main types of CMS: Adaptive tools, Micro-adaptive tools, and Lecture capture system. In micro-adaptive tools range it is hard to find open systems. Adaptive tools are the course management systems where a specific content for the person's course can be created. Moodle is an example of free adaptive CMS (See, 2014). Micro-adaptive tools are more complicated in development of courses and more adaptive, and now most of them are not open. The VLC were born, start from the technology of screen capture which basically allow copying and recording what is currently presented on the screen and producing screenshots or videos. Now there are tools like Panopto Echo 360, which create video content out of the webcam and the information from a screen like PowerPoint slides by screen capture software (See, 2014).

So professor can record himself/herself in front of the computer and reproduce face-to-face (F2F) connection virtually. The part of the screen occupied by the professor and the part by slides, only defined segments can be watched. Also the activation of the slides can be realized by Adobe Presenter, which uses Power Point slides and creates tutorials (See, A, 2014). One more lecture capture system is Polimedia, which creates multimedia content. It requires to record info in a studio and allows translating content and developing different language courses for the international education platforms. The Automated Speech Recognition systems ASR translates captured voice in multilingual subtitles (Miro, 2014).

The most interest from the different open sources of information s MOOCS and platforms for them. The massive open online courses have a global access and appeal to a huge number of people of different nationalities and backgrounds and give ability to learn, communicate peer-to-peer in a global scale (Brahimi, 2015). MOOCs main providers are USA (Coursera, edX, Udacity), Europe (FUN, Iversity), UK (FutureLearn), Middle East (Rwaq, Edraak), or in Australia (Open2study) (Brahimi, 2015). Key of them are non-profit edX (<http://www.edx.org>) and a for-profit Coursera (<http://www.coursera.org>), both of them give synchronous form courses with publishing content at concrete time and date (Burd, 2013).

Open education gives wonderful results and possibilities. Advantages for students are obvious: a lot of free sources for study and subsequently open policy of backward universities and forced fee reduction by universities (Burd, 2013), (Bowen 2013). Lowering costs by increasing productivity, while preserving quality and protecting values (Bowen 2013). However, some problems for other participants exist. On the MOOC's example of open sources it is easier to clarify the gaps regarding open education. The monetization model of it is still not clear and how MOOCs influences on prices of education and what organizers achieve. Funds problem touches other open sources also, part of them cannot cut the expenses (Zhang, 2012). First reason is low rates of competence courses 5-15 % (Burd, 2013). Also it is hard to attract future students to university because it was found that more than 80 percent of participants already have a degree. It means that market is for postgraduates (Burd, 2013) and business models must admit it. Perspective business models are: (a) charging for certificates, (b) linking students with potential employers, and (c) charging for

supplementary services. A specific analysis by Moody's Investors Service identified these opportunities (Burd, 2013).

Open education is a massive participant among blended learning types which give birth to flipped classroom concept, development of resources to education and training. In that way the **gaps** connected to it can be faced straight in flipped classroom. The main question is how to apply the open concept for flipping in an economically effective way?

### 3.7. Adaptive learning

Adaptation in education directs straight to the individual skills, pace, progress, needs and way of study. Two ways of adaptation using technology are applied. First when teacher adapts his/her course to the students or students try to frame up in professor's course. However the second way can be assumed as a standard with implementing technologies. Traditional education implies that students have to be prepared to the lecturer adapt to not always convenient curricular, adapt to uncomfortable atmosphere and style of teaching material.

The technological tools support adaptation. It is embedded into each of our devices. The progress runs fast and all our life technologies become more and more intuitive. Educational sphere is not an exception. Evolution of adaptive systems starts from tracking systems which follow the student activity before and after the class, then were blended learning systems with feedback, blended learning for mobiles and etc. Nowadays, the most progressive adaptive tools are Course Management Systems (CMS) or it can be named Course Development Systems (CDS). It is still constructors but with a huge instrumentation range which the developer creates in HTML. Courses may be developed in offline or online environment, depending on software package. Online courses are made by e-learning development programs and allow monitoring the activity of participants online, and giving more other evaluating mechanisms and forming centralized control (See, 2014). They are also called micro-adaptive tools these tools are more detailed. The offline courses-adaptive tools present common constructors with less personalized material. The course developed in an e-learning environment is a visual

manual with simulation of a real world processes or situations and contains evaluation system at the end (Kakosimos, 2015). Micro-adaptive tools like Articulate storyline, Smart Sparrow®, Knewton allow to create a scenario driven content and the results of answers can be monitored instantly (See, 2014). Basically it can be implemented to each type of learning. In the article the principles of development instructions for students are presented. Using this software, the interactive content for learning outside the class with tracking the activity of each learner can be easily developed. The program allows professor to prepare familiarizing materials and test its assimilation not in or after the class but before it. This feedback helps to adapt in class session for individuals and address all misconceptions. Three types of getting the feedback is used: (a) quizzes and problems, (b) self-assessment questions and (c) user's interaction with the platform (clicks, active time) (Kakosimos, 2015). Moreover the content can be assembled in that way that number of different paths can be created for structuring the material. Thus adaptation and dynamic is backed up, keyed to various levels of understanding. Attention of the user is appealed by adding animated characters, which modify and diversify the content.

The applicability of such software is not limited by educational area. Universities are not the only actors, who use it for training courses for the professors or students. In a business environment Virtual Learning Environments (VLEs) presented by training course programs got a success because of decline in training costs for employees and rising the return on investment (ROI) (See, 2014). The cost reduction is achieved by covering (training) plenty of people with minimal resources (See, 2014). Adaptive e-learning tools solve two problems: allow anyone easily develop the course, satisfying the needs of exact topic and keep this course and resources updated.

Mainly, positive attitude about this tool, regarding to helpfulness for the professors in preparation materials and in student understanding, was confirmed. However, it requires a lot of efforts from professor to upgrade materials (Kakosimos, K. 2015), a lot of additional time from professor and student and being used with technology implementation (See, 2014). This adaptive tools also can be implemented for a flipped classroom, giving additional improvements (Kakosimos, K. 2015) and the main gap, is it resource effectiveness to apply this tools. It can work with analog with business -cost saving as people spend less time and easily update training programs. The number of

trade-offs for implementation exist. Possible solutions to teach professors to use these platforms or to outsource partially the responsibilities. Additional feasibility impact analysis of this MAI (micro-adaptive instruction) on professor, university and other stakeholders can be held and estimation of resources, such as time, money and efforts can be provided for the long-term planning.

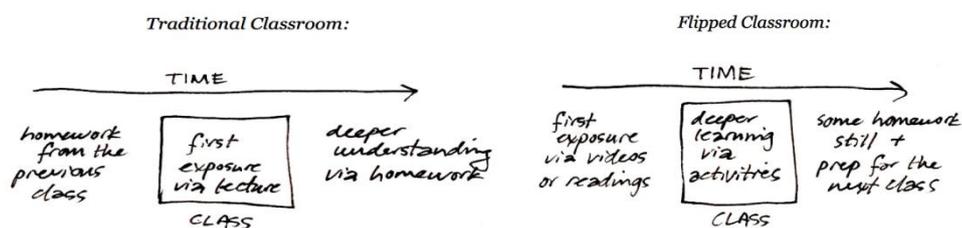
### 3.8. Flipped classroom

Flipped classroom is an overall term for the reverse traditional education arrangement. In some sources it is also called blended learning, or the inverted classroom, condensed classroom, post-lecture classroom (Plasencia, 2014), (Bergmann & Sams, 2012). It is definitely one from other types of mixing learning. It is one of the most recently emerged nearly in 2012 innovative and popular technology-injected learning models. It combines variety of technical tools. One group aims to create and reproduce video content and the live environment is maintained by another - active technologies (Jensen, 2014). “The core idea is to flip the common instructional approach: with teacher-created videos and interactive lessons, instruction that used to occur in class is now accessed at home, in advance of class. Class becomes the place to work through problems, advance concepts, and engage in collaborative learning” (Tucker, 2012). Most activities in class are automated by using clicker responses, low- or un-moderated online discussions, quizzes, and so forth (Bogost, 2103). After the class students can apply their knowledge and deepen into material.

### 3.9. Traditional and Flipped classroom

Best visual explanation of the concept is to show the comparative analysis of traditional classroom and flipped classroom. Figure 3 gives the sketch of the two concepts. Each process is separated in time on 3 main parts, 1<sup>st</sup> one is activity before class, 2<sup>nd</sup> in class, and 3<sup>rd</sup> after the class. A traditional classroom has usually no preparation to the class

some homework or sometimes readings before class, lectures during class, and assignments or homework after class (Bogost, 2013). A flipped classroom has lectures before class in a form of short videos or short courses developed in CMS. Flipped classroom meetings in class consist of practical activities with additional assessments and exercises (Bogost, 2013). Most of them are non-synthetic and automated by using technologies. Interactive systems include feedback systems, response systems, clickers, online discussions, blogs and chats, exercises during class, and assessments after class.



**Figure 3. Comparison of traditional and flipped classroom.**

As stated earlier, evolution model of flipped classroom is not new but the system of delivery of the same information “deposited by old classroom techniques” is (Job, 2016). This is some kind of inverted open course partly online as video preparations and partly in class as activities with a tendency of student as a moderator of learning. Students come to the class already prepared with the offloaded videos or CMS and class time is fully directed to engage student in active learning (McLaughlin, 2014) and define the student gaps in one’s knowledge or interests easily. However, the lecture still exists in the flipped classroom, students listen to it before the class, not in it (Bogost, 2013).

The difference just in structure of the same information given and applied technologies seems not to give significant discrepancy in results or in use of resources. However the huge number of comparative researches of quantitative results for traditional classroom and flipped one prove the opposite. Mainly the results of improvement can correlate with previous methods implementation. For instance, if active technologies are used for the flipped class, it brings its benefits.

### 3.10. Results from the previous researches of flipped classroom

Table 2 below gathers all the results, which describe improvements in different researches of flipped classroom implementation. More than 15 studies in 8 different fields were considered. Each research contains comparative analysis of parameters for traditional and flipped classroom.

Three main parameters, which gauge about the effectiveness of the method: 1) Score of student, 2) Student satisfaction, 3) Professor satisfaction. In addition to them, indirect indexes compose the effectiveness level. First is activation of the class, including communication between peers, interaction between students and professors, arguing and other ways of participation. Also personalization is an indirect factor measured by increase individual time of interaction between professors and by personalization of instructions. Student satisfaction straight connected with adaptation to new concept. Professor satisfaction connected with feeling of improvements. Resource effectiveness, which compounds the main interest for that research is measured by covered material and free time in class, decrease reservation of space for the class, decrease efforts of professors. In covered material most of the professors make an accent on covered gaps. All these compound the cash component.

**Table 2. Flipped classroom improvements**

Index	Score	Student satisfaction	Adaptation	Activation of the class		Personalisation		Professor satisfaction	Covered material
				<i>Communication between peers</i>	<i>Activation of the content</i>	<i>Increase of communication</i>	<i>Personalise instruction</i>		
<b>Researches with improvement</b>	6+	3+ 3-	+1	5+	4+	3+	4+	2+	3+

**Scores:** Number of experiments show scores increase after flipping. Flipped classroom arranged by adding more preparation video materials. For engineering (Mason, 2013), information systems (Davies, 2013) and computer courses (Kim, 2014) test performance is more favorable. In the same structured experiment for psychology department (Tune, 2013) average increase of learning outcomes is 15%. One more experiment in the class for nurses contain comparison of three lecture forms: traditional lecture only (LO) lecture and lecture capture back up (LLC), and the flipped classroom approach of lecture capture with innovative classroom activities (LCI). The exam scores of students from LCI group were higher than LLC on 15% and LO on 10% (Missildine, 2013).

**Activation:** In some researches it is supposed that mainly class activation lead to better test performance. Thus, different improvements in class activation lead to outcomes growth. The study of just active classroom results in better test performance on  $\frac{1}{3}$  (Hannah Richardson, 2010) in chemistry by using clickers also in physics on 15% percentages (Ankeny, 2014). Also it brings the increase of speed of the discussion (Hennessey, 2014) and attendance of the lecture achieves 80-90% (Ankeny, 2014). The number of researches of flipped classroom elicits the communication rise between peers in Anthropology (Elaine, 2013), where the experiment formed that way, that preparation videos peers find by themselves for the future topic, and share between each other. The cooperation between students increase on 25% with the number of innovative methods used, (Strayer, 2012) and in computer engineering department (Kim, 2014) with the rise of using familiar technologies (Mary Beth Gilboy, 2014). Students are more willing to participate in inverted classroom (Strayer, 2012) which is the best solution for large classrooms to increase face to face communication (Paul Baepler, 2014). Also Khan in his videos talks that ability of interaction of students in class results in humanization of the lesson (Khan, 2011).

**Personalisation:** As soon as homework done before the class, there is more free time for personal communication between professor and student (Bergmann and Wilie 2012). On average, teachers spend more time with students during the class in 10 times. Discipline in which was demonstrated improved student-teacher real-time interaction is healthcare (Mary Beth Gilboy, 2014). Also positive changes regarding face-to-face student teacher interaction were revealed in (Kim, 2014). Personalisation (10%) of 10 % of the material and individualisation (8%) improved (Strayer, 2012). Khan notices that personalisation

of material results in adaptation courses not only for level of middle students but for all. And different level students comprehend information without gaps and more prosperous students develop in the activation manner (Parslow, G. R., 2012).

**Student's attitude:** As soon as all new methodologies conceived with challenges, not only for students but for professors also. Because it is harder to assimilate new material and it requires more efforts to use and introduce it first time. Not all students are satisfied with it. Missildine (2013) writes that the satisfaction with the inverted classroom is lower. However during the Anthropology Foundation program, where Face- to- face lectures were supplemented with Youtube videos to informally familiarize student with the topic virtually, positive attitude to work with videos were achieved (Elaine 2013). The choice for the video was free. So the student found the videos for themselves. Also in the engineering courses flipping experiment students satisfied with it and finds it more effective (Mason 2013).

**Student's adaptation:** Sometimes adaptation depends on student's attitude, so if students are not satisfied, they got more problems with adaptation. Mason (2013) noticed the fact that adaptation of students is fast and Paul Baepler (2014) noticed improved perception.

**Professor attitude** mostly formed by the improvements that they can achieve for students and for themselves which can be measured by scores and attitudes for students and and improvements for their practices (Tucker, 2013).

**Resources (Covered material, Time, Space):** Time spent in class influences amount of covered material and the occupied space. So decrease of time changes depending parameters. In some studies created learning environment by flipping reduces the time in class on 66%, which means increase of covered materials and reducing the class time (Paul Baepler, 2014). Special interest presents covering more gaps which still left as misconceptions for the students. For engineering course more material were covered (Tucker, 2012). Bergmann (2012) told that he can more easily cover gaps and misconceptions and incorrect assumptions of the students.

All this previous results show that flipped classroom with combination of previous methods in it, is an effective method. However, professor view and resources

distribution in the inverted classroom had not fully observed in other works. And still the question about resources is not elaborated in a previous researches sources and materials.

Some biases in the results analysis in some researches were revealed, first in comparison of flipped and active classroom, second is about improvements for flipped classroom borrowed from adaptation technologies, also the doubtfulness of the future popularity of the topic and technologies implementation. All this uncertainties are discussed further.

### 3.11. Flipped and Active classroom

Here the misconception is going to be broken about the research from department of biology, that active learning and flipped classroom have no difference in results. In the article (Jensen, 2014) somehow opposite to others authors prove the fact that flipped classroom on its own has no benefits and all the improvements area result of active instruction part of the classroom, than of the order in which facilitator (professor) arranges the class. In brief explanation, in the article active and flipped arrangements are compared. After the classes students from two groups, of practically the same sample, go through a number of quizzes which combine 3 exams, each of them consisted of 75 multiple questions and 39 assignments. For both groups the exam and assignment scores were practically the same. After that the feedback in the form of questions about helpfulness of the arrangement of the course were collected and students from flipped classroom had given worse attitudes on nearly 10 percentages than from active.

Finally, it can be concluded, that in this experiment in department of biology in Brigham Young University there are no improvements in flipped classroom comparing to the active one. Let us consider the scheme of arrangement of the classes from the article on the Figure below.

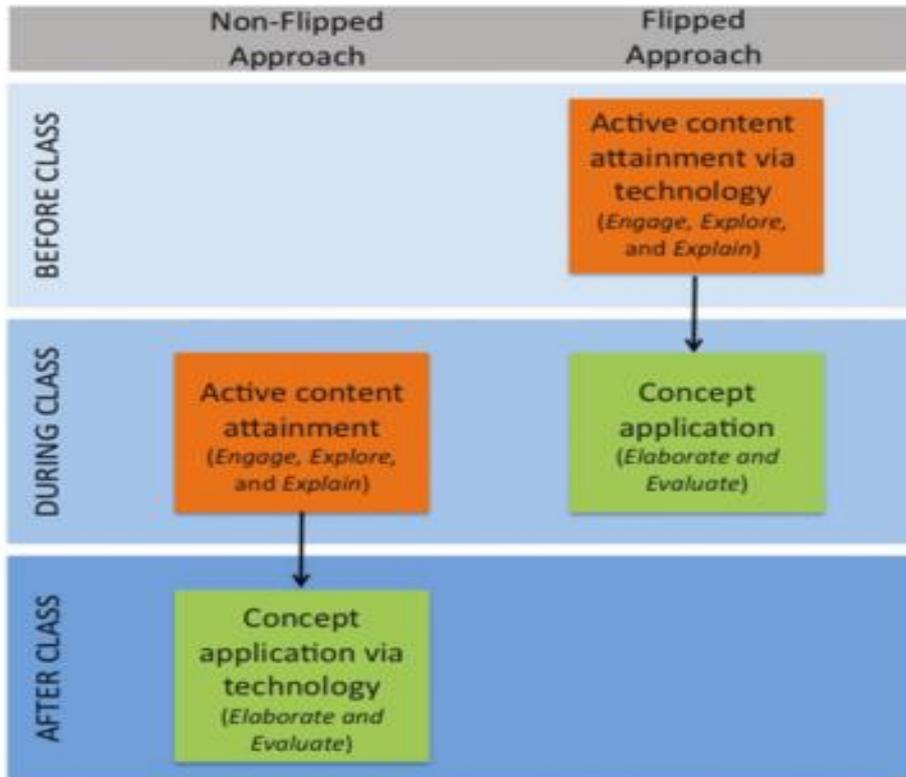
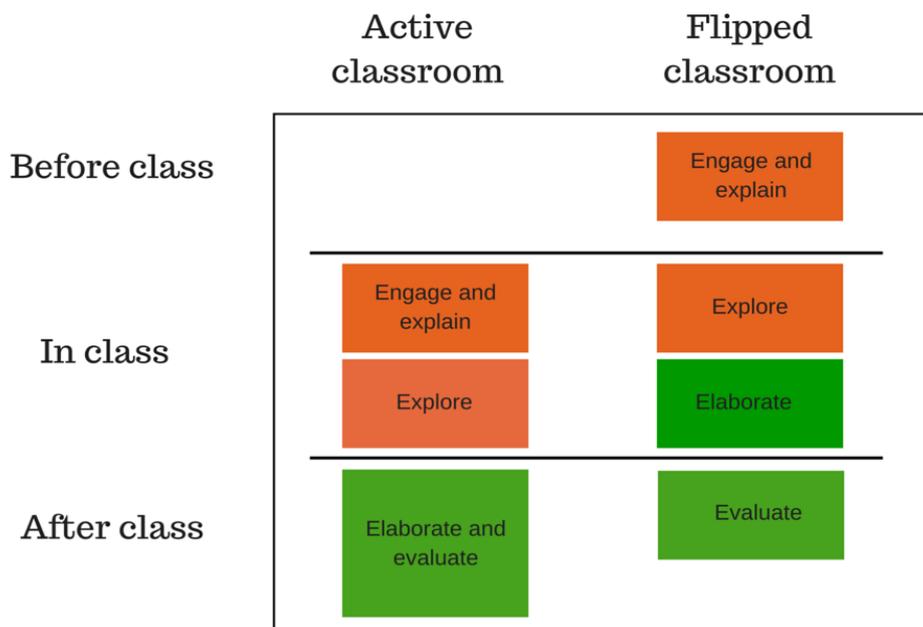


Figure 4. Non-flipped and flipped structure (Jensen, 2014)



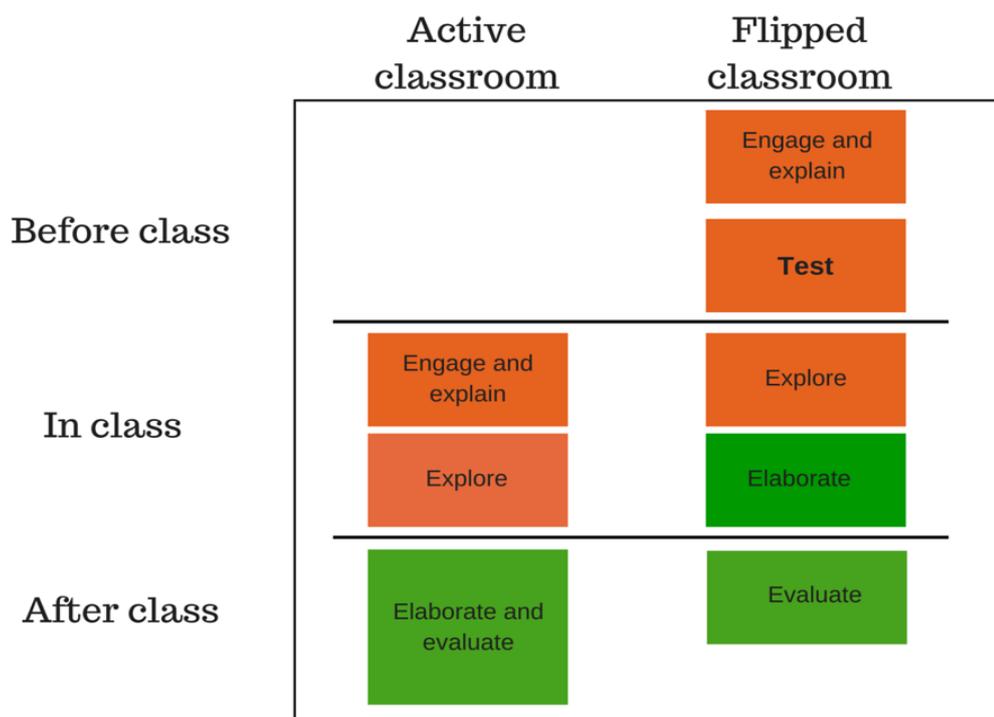
### Figure 5. Non-flipped and flipped structure

In Figure 4 in active class nothing happens before the class. In class familiarizing with the topic goes first, than active content and after deep in material online. In the flipped model comes engaging and familiarizing with topic content before the class and then elaboration and evaluation occur in class. It seems that in structure for the models really important part is not separated in time. Let us assume the modified Figure 5, which describes standard conception for active and flipped approach using the terms presented in the article. In non-flipped classroom active part should be separated in two ones. In that case, in the class student should first familiarize with the topic and then implement it on practice by using active tools. And after the class elaboration and evaluation occur. In the flipped classroom active blocks are separated in time before and in class, elaboration is in class and evaluation can be in or after. This separation creates more free time in class and allows going further. Preparation stimulates and maintains the activities in class (Bergmann and Wilie 2012). Also it allows covering more gaps by giving time and ability to students to prepare questions and somehow moderate lecture. Without it, like it is shown in active class the professor doesn't really know, if the students are ready to elaborate. Moreover, such results as time spent was not measured, submitted or taken into account in this study. The scores for assignments or quizzes cannot measure these results only by a feedback and additional counting the time resources.

Finally, it can be concluded that most of authors analyze the scores of the students after implementing the flipped classroom and in a majority; studies achieve positive results for the effectiveness of the class. However the researches limit only to effectiveness of education, do not take into account impacts and resources, which can not be measured by score and advantages or disadvantages for other participants of the educational process. Also the satisfaction of students in a number of researches low, because of need of extra time and efforts from students and professors and need to use technologies (Missildine, 2013). This problem exists in both variations of flipped classroom realisation, using video or micro adaptive instructions (Missildine, 2013).

### 3.12. Flipped and adaptive classroom

Flipped classroom as it is basically formed has a huge gap in its preparation for the class. With the concept of flipped classroom students can adapt to the class before using the materials, which are given (Kakosimos, 2015). The problem with a classroom time, limited face-to-face meetings and student resistance is solved (Kakosimos, 2015). The main disadvantage of common flipped classroom where videos used it cannot measure the preparation and don't follow out of class activities. Teachers just guess that all students come to the class already prepared. Moreover, like in traditional classroom students avoid doing their homework in inverted classroom. They postpone preparation for the class, trying to do it later or all straight before class they felt guilty but it doesn't help (Strayer, 2012).



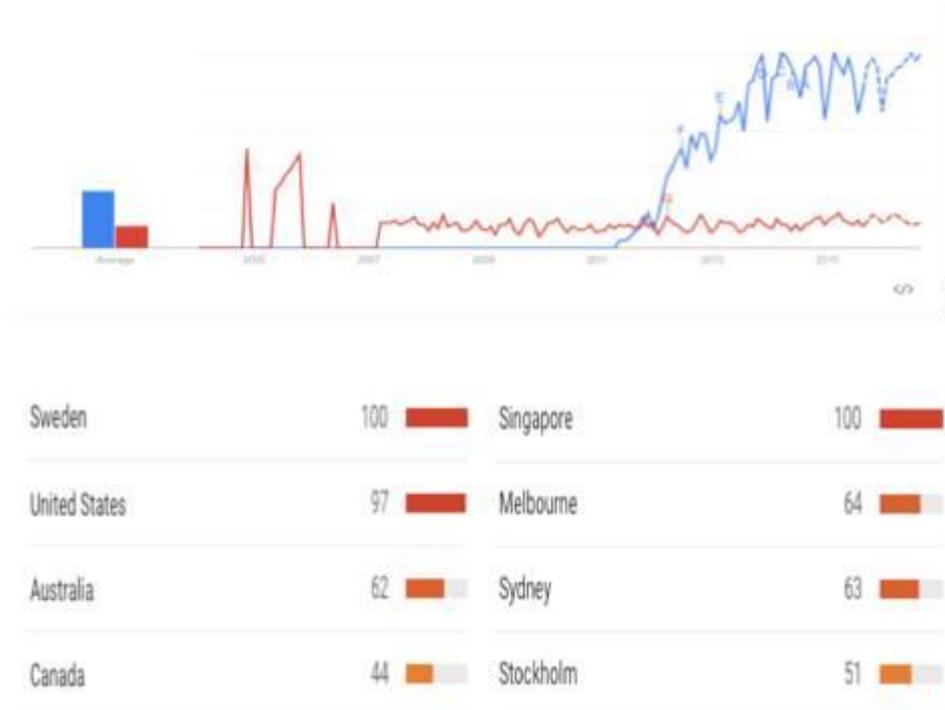
**Figure 6. Non-flipped and structure**

To solve that problem, the pretests or micro-adaptive instructions should be used before

the class students should watch preparation video and right after that test him/herself (Figure 6). Or go through micro-adaptive lectures with testing in it. Both this methods allow professor to get instant feedback and modify next class, covering main gaps for the students.

### 3.13. Future of the concept

There are a huge number of concepts in education and new appear from time to time but a lot of them just fade quickly. There are a numbr of factors, which are influence popularity of flipped classroom concept. All online concepts expand their positions: online education, open technologies, video technologies. The statistics of growth of in use open concept like MOOCs support the idea of flipping as contain compareable organization of the classes. The most famous platform Coursera have 16,643,278 learners·1,519 courses·140 partners and the amount constantly growth. As soon as flipped classroom assembled from them and contain an online and open element-preparation before the class, this tendency can be applied for it also. This online and open technology uses growth connected with the changes in the lifestyle tendencies like shifting environment, technology widespread use, availability and visualization of information, huge amount of sources of information, constant interaction and mobility. Popularity of video as an education method is also clarifies actuality of the concept which can be measured by downloads or views on Youtube, Khan videos, and other video contained resources (TED, BBC). Khan Academy is the most well-known of the flipped classroom models. According to Khan website, since its founding in 2008, Khan Academy has delivered 374 million lessons to an average of 10 million unique users per month in 200 countries. The content on the website is translated into 28 different languages (Khan, 2011). The popularity of the term in google search in last time, which presents interest trend over time, regional interest by country and by the city in the Figure 7 below.



**Figure 7. Popularity of the term.**

Moreover the amount of papers in the largest databases increased from 2011 year from 15 to more than 150 a year in Scopus database. The best universities according to The World University Rankings write about successful flipped classroom implementation. Caltech California Institute of Technology, Harvard University, Oxford University, Stanford University, Cambridge University present their own approach for flipped classroom.

If we change the area from educational to business it can be noticed a number of similar concepts used for training. It is applied in the form of adaptive instructions or video courses which are delivered straight to the employers to teach or train them to the defined aspect. This flipping model with outsourcing content is used in many business fields and brings benefits and rises its popularity.

“The idea of flipping the classroom is not new (Pardo et al. 2012), but the idea has recently gained prominence due to advances in technology and increased ubiquitous

access to 123 College-level information systems 565 computers and other mobile devices” (Davies and West, 2013).

Different opinions formed about flipped classroom revolution and on the example of Khan approach it is still not studied in a long term perspective for it and is this approach becomes “real or failed revolution. ”.”In any event, the intense interest in the flipped classroom is good for education” (Tucker, 2012). It rises the interest to the education problems amount of researches about it. Definitely “in today’s highly polarized political environment, it also runs the risk of being falsely pigeonholed into one of education’s many false dichotomies, such as the age-old pedagogical debate between content knowledge and skills acquisition” (Tucker, 2012). However from the other side potential new group of learners can be attracted with the new concept, and this a competition between universitites which can not be disregarded (Panto, 2015)

This approach is still studied and has a number of gaps: comprehensive research model, insufficient discussion of digital learning platforms, and lack of design guidelines for course activities (Yunglung, 2014)

### 3.14. Redesign for flipped classroom

One of the gaps is lack of design guidelines for the course. First of all the specific for each course require beforehand clarify the course expectations (Wilson, 2013). Taylor writes a lot about how to find approach for today's students and advised to emphasize on shifting education to distance/online environment, increasing activity in class, force necessary preparation for the class and develop skills for the future (Wilson, 2013). The arrangement of class class contains preparation in different forms for stimulating preparation. Quizzes and tests are also included (Wilson, 2013). In class activities are arranged specifically to a course.

Crucial effect for the arrangement brings technological tools. During literature review the question about appropriate applied technologies were stated. Some groups were analyzed and registered in a table 3 below. Flipped classroom first part before class can be realized by using video, advanced video tools, CMS, Presentation activators and LCS.

Such common tools as textbooks, which also can be used for preparation are not examined. For activation in class time interactive systems like feedback can be applied. Somehow, it can be concluded that flipped classroom gather previous methods technologies. The table 3 gathers all the technologies for flipped classroom, for both of its parts. Also the type of classroom where this technology was originally used is presented in the table.

**Table 3. Categorization of technologies**

<b>Type of classroom, where toll applied before</b>	<b>Tool for flipped classroom</b>
Preparation part	
Open education /distance	Video+Tests
New	Advanced video tools
Adaptive education	CMS -microadaptive tools
Open education/distance	CMS- adaptive tools
New	LCS
New	Presentation activators
Active part	
Active education	Feedback systems
Active education	Presentations (visual tools)
Open education/distance	CMS-VLC

Two components needed for preparation for the class: the video/visualized material and they can be mixed. There are two most effective types of the materials: develop video and tests or include it in the part of CMS and second option is to develop material using

course management systems, which already contain testing parts. Video can be developed using any video recorder or web-camera on your computer or other camera. Video can be edited using animation and any other editing programs. Also the video can be developed already in VLC program, which helps you to correlate video with presentation slides. Another variant is to visualize your already existing slides in Video Presenter. After that, test can be provided or video inserted in CMS, like Moodle. Another variant create interactive visualized material using CMS or Course development systems like Articulate Storyline. All the options are present in the table 3.

For active part of the class main interest represents feedback systems. As soon as they can be applied for different classes and do not require special equipment. During the second experiment one of these systems will be deeply reviewed.

### 3.15. Summary. Main Hypothesis.

It is supposed that flipped classroom implementation is beneficial for the professors and resource effectiveness.

**The hypothesis for this research is formed based on the literature review:** “The flipped classroom is a long-term perspective concept, which implementation cut the lecturing time owing to declining amount of repeats.”

## 4. Data analyses

Empirical studies are conducted to reveal the professor's work and attitude towards the flipped classroom. The two-layer approach is used, where first comes questionnaire and then experiment. The data analysis in this part foregoes results and discussion. There was not so much insight about professors' point of view is revealed by the literature review, therefore the main aim of this part is to gather real professors opinions. To learn more about the concept, check their lecturing type, gaps in understanding and possibility of flipped classroom implementation.

Planning of the study starts from developing an advance questionnaire based on literature review. There were developed three versions of the questionnaires and sent to overall 50 professors from different universities. Sample includes 30 professors from Lappeenranta University of Technology (LUT) in the industrial engineering and management department, 10 professors from Peter the Great Saint-Petersburg Polytechnic University (SPbPU) and 10 professors from other universities. Each form was adapted to particular group without radical changes. The form contains introduction material, 11 questions in the first part ("In general") and 9 questions in the second part ("Applicable to your course"), also there is some space for name and comments. Introduction material familiarizes professors with the topic. First part consists of descriptive questions about general professor's attitude to the flipped, active and traditional classroom, to the technologies' implementation. The second part of questions ("Applicable to your courses") is available for the professors, who answered in first part that they would like to flip their class. There are questions about their courses like amount of hours, percentage of repetition, level of upgrade, which describe the professors' lecturing.

Two main experiments are carried out. Each of them composes a flipped classroom arrangement. First experiment simulates preparation part for inverted classroom. Second experiment reproduces the activities for the class. Each of these practical activities has 3 main steps. Preparation step, where all organizations are planned, attempting/testing step, where the experiment is conducted and evaluation step, where the results are combined and evaluated. The first experiment aimed to describe the organization of the process for video content developing. It includes 5 concrete steps:

- 1) Find the professor from the sample of questionnaire, the main factors to lean on are desire to take part and the ability to apply concept to their courses;
- 2) Make a sketch for the rebuilding or recording fragment of the lecture;
- 3) Record the video with professor;
- 4) Process and upload this video;
- 5) Gather the statistics.

After the final step, the resource effectiveness can be counted using questionnaire

gathered values and experiment results.

The second experiment aimed to show a simple way of activation of the class, using the feedback system. The process includes:

- 1) Find the professor, who would like to openly apply interactive system for his/her class;
- 2) Apply the program with assistance;
- 3) Gather the feedback, straight through the system.

### Variables for the questionnaire

Some of variables are computed and remarked with formulas. Table 4 describes each variable.

**Table 4. Variables for the questionnaire**

Variable in SPSS (ID)	Description or Computing	Question
Approach	Approach used	What approach do professors apply?
FlippedClassroomFame	Flipped classroom fame	Have you ever heard about flipped classroom?
EfApproach	Effectiveness of the concept	What is the most effective approach?
EfApproachForY	Effectiveness of the concept for your lectures	What is the most effective approach FOR YOUR LECTURES?
ShiftComponents	Shift components to flipped classroom	What are the components for the shift?
ShiftBarriers	Shift barriers to flipped classroom	What are the barriers for the shift?
EfTechnologies	Effectiveness of the technologies	Do you think that technologies are effective for education?

UsedTechnologies	Technology used already	What technological tools do you apply in
TechUseBarriers	Technology use barriers	Why you do not apply technologies?
DesireFlip	Percentage people which desire to flip	Do you want to implement flipped classroom?
<i>Ability to apply to professor's courses</i>		
AmountOfCourses	Amount of course in one year	How many courses do you have in a year?
CourseHours	Amount of lecturing hours in a year	How many lecturing hours do you have in a year?
RepetitionRate	Amount of repeats lectures in a year	How many times do you repeat the same course in a year?
LifePeriod	Duration of the course	What is a life period of each course?
UpgradeRate	Rate which upgrade for each course	Which part of the course do you upgrade every year?
InvariableRate	The part of lecture stay unmodified	Which part of the course stays invariable during life period?
<i>Factors influencing on the way of flipping</i>		
DesireFreeTime	Desire to free time from lecturing	Do you need to free some time in your lecturing?
DesireLowRepetition	Desire to low repetition of the same material	Do you need to low repetition in your lecturing?
DesireRecord	Desire to record video course	Do you want to record part of

		the lecturing material?
DesireShare	Desire to share materials openly	Do you want to share openly your lectures?
RepetableHours	=InvariablePercentage*Lecturing Hours	Computed variable
AmountOfRepeats	=RepetitionRate*LifePeriod	Computed variable
LecturingTime	=LecturingHours*RepetitionRate *LefePreiod	Computed variable
LecturingwithRepeats	= RepeatableHours*AmountOfRepeats	Computed variable
ModifiedHours	=LecturingTime-Lecturing with repeats	Computed variable

For the questionnaires part, first factor analysis is used. It helps to define factors influencing the process of flipped classroom implementation. Factor analysis contributes to picking out most important correlations for this study. After that One-way Anova analyses helps to check impact-defined variables. Furthermore, strong enough correlations revealed in the factor analysis, are clarified using bivariate correlations, graphs and figures.

The design of each experiment was developed by the author of the thesis. Its description and components evaluation presented in the results part and discussion.

## 5. Results

### 5.1. Questionnaires

#### 5.1.1. Revealing the correlations. Factor analysis.

Factor analysis aims to define the correlations between variables and combine them into groups to decline the number of factors, which are going to be used further. The variable, which has low correlation with all others, can be eliminated from further comparison analysis. The principal components were identified, as main method for factor analysis. If the value tends to 1, the correlation is positively increased. In case if the value close to -1, the negative correlation increased. At the beginning, to simplify analysis, all the variables were divided into three main groups. Three main correlation tables were developed to estimate correlation between approaches, define the conformity of the course and desire to flip. Table 5 below contains the variables, reveals and questions for each group.

**Table 5. Groups for Factor Analyses**

Group	1	2	3
<b>Variables</b>	Approach FlippedClassroomFame EfApproach EfApproachForY DesireFlip	AmountOfCourses CourseHours RepetitionRate LifePeriod UpgradeRate InvariableRate	DesireFreeTime DesireLowRepetition DesireRecord DesireShare
<b>Question</b>	Is any correlation between approach used and preferable approaches?	Is any correlation between the numbers which characterise the course?	Is any correlation between desires to work with the materials?

<b>Reveals</b>	Correlations between approaches and desire to flip	Conformity of the course	Desire to flip
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### First group

For the first group, there is no strong correlation between desire to implement flipped classroom and approaches already used or most effective ones. The strong correlation is between approaches, which professor uses and his/her knowledge about flipped classroom was discovered (0,554). Also it is clear that strong correlation exists between most effective approach, which professor chooses and most effective for his/her own lectures (0,435). Significant positive correlation is between effective approach and approach which professor use (0,400) and practically the same for their lectures (0,367) (Table 6). The reliability of the data presented by the determinant for this correlation, which value 0,326 is significantly more than 0,001. In KMO and Barlett's test table the Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0,486 as it should be approximately or more than 0,5 (Table 7). The data also can be checked by using Pattern Matrix in Table 8, where the correlated variables present construct with close means.

According to this information, further comparative analysis between “Approach”, “EfApproach”, “EfApproachForY” is necessary.

**Table 6. Correlation Matrix for first group**

Correlation	FlippedClassroom Fame	EfApproach	EfApproachForY	DesireFip	Approach
				51	
FlippedClassroom Fame	1,000	,200	-,088	-,151	,554
EfApproach	,200	1,000	,435	,293	,400
EfApproachForY	-,088	,435	1,000	,094	,367
DesireFlip	-,151	,293	,094	1,000	,000
Approach	,554	,400	,367	,000	1,000
Determinant = ,326					

**Table 7. KMO and Bartlett's Test**

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	,486
Bartlett's Test of Sphericity Approx. Chi-Square	16,240
df	10
Sig.	,093

**Table 8. Pattern Matrix**

	Component	
	1	2
FlippedClassroomFame	-,113	-,892
EfApproach	,779	-,249
EfApproachForY	,738	-,071
DesireFlip	,622	,394
Approach	,380	-,780

## Second group

There are strong negative correlations between rate of upgrade of the course and rate of material, which stay invariable. The more level of first variable, the less level of the second. The correlation is not too high that it can be ignored; it is less than 0,8 (-0,761). Also these two variables correlate with the life period. The more life period of the course the more upgrade level (0,491) and t the less invariable level (0,527). Significant correlation is relieved between amount of courses and lecturing hours. Also the level of repetition correlates with amount of courses (0,534). And strong enough negative correlation is between amounts of course and upgrade rate (-0,453). It is important to emphasize that there are no strong correlation between amount of courses and invariable rate and between lecturing hours and upgrade and invariable rate. However each of this couples correlates strong with each other (AmountCourses and LecturingHours, Upgrade Rate and Invariable Rate) (Table 9). The relations of amount of courses and repetition and upgrade rate do not represent interest for this study, because the lecturing hours computed using amount of courses and practically it does not matter what is the amount of courses, because the lecturing hours can be unpredictable.

It is significant to compare upgrade, invariable rates and life period. Also the interest present research “Repetition rate” and “CourseHours”.

**Table 9. Correlation Matrix for second group**

	AmountOfCourses	CourseHours	RepetitionRate	LifePeriod	UpgradeRate	InvariableRate
AmountOfCourses	1,000	,626	,534	,040	-,453	,166
CourseHours	,626	1,000	,122	,077	-,184	,118
RepetitionRate	,534	,122	1,000	,205	-,187	,164
LifePeriod	,040	,077	,205	1,000	,491	-,527

<b>UpgradeRate</b>	-,453	-,184	-,187	,491	1,000	-,761
<b>InvariableRate</b>	,166	,118	,164	-,527	-,761	1,000
a. Determinant = ,057						

### Third Goup

The variable, which influences mostly the desire to flip “DesireRecord” has no strong correlation with others. However positive strong correlation is between desire to free time and decreasing amount of repeats (0,423) and between free time and sharing openly (0,423).

**Table 10. Correlation Matrix for third group**

	DesireFreeTime	DesireLow Repetition	DesireRecord	DesireShare
DesireFreeTime	1,000	,423	,149	,423
DesireLowRepetition	,423	1,000	,218	,238
DesireRecord	,149	,218	1,000	,218
DesireShare	,423	,238	,218	1,000
Determinant =,619				

Finally it can be concluded that correlations between these parameters, which presented further should be provided. Correlation between approaches will be assumed. Also between parameters of arrangement of courses: UpgradeRate, InvariableRate, Life Period. In addition, the cumulative factor analysis which include all variables provided identify the relations between variables from different groups. Approach and amount of lecturing hours are dependable (0.426), as well as approach and invariable percentage (0,525).

#### 5.1.2. Approaches and their effectiveness

Choices of approaches are provided with descriptive statistics and frequencies. In table 11 below the statistics for the concepts is gathered that professors normally use, and professor's acquaintance with the inverted classroom.

**Table 11. What approach do professors apply?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Traditional	4	16,0	16,0	16,0
Active	15	60,0	60,0	76,0
Flipped	1	4,0	4,0	80,0
Valid Active+ Flipped	2	8,0	8,0	88,0
Traditional+Active+Flipped	1	4,0	4,0	92,0
Traditional+Active	2	8,0	8,0	100,0
Total	25	100,0	100,0	

The highest percentage of professors applies active approach (60%). Traditional approach is applied by 16% of professors. Only one professor chooses pure flipped approach. The rest are about mixing methods within which flipped exists. In sum 16 % of the respondents apply flipped classroom. There are no missing values, all the respondents answer the question, that is why the percent and valid percents are the same.

**Table 12. . Have you ever heard about flipped approach?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid No	8	32,0	34,8	34,8
Yes	10	40,0	43,5	78,3
Yes and Use	5	20,0	21,7	100,0
Total	23	92,0	100,0	
Missing System	2	8,0		

Total	25	100,0	
-------	----	-------	--

Answering the question about familiarity with the approach, high percentage of respondents (32%) admitted that they have never heard this term «Flipped classroom». However, couple of them commented that they have tried something similar being unaware of the term. Less than a half (40%) of professors heard about the concept and approximately 20 percentages not only heard but also use. It means that 72% percent never tested flipped classroom (Table 12).

**Table 13. What is the most effective approach?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Active	8	32,0	38,1
	Flipped	5	20,0	61,9
	Active+Fliped	3	12,0	76,2
	Traditional+Active+Flipped	5	20,0	100,0
	Total	21	84,0	100,0
Missing	System	4	16,0	
Total	25	100,0		

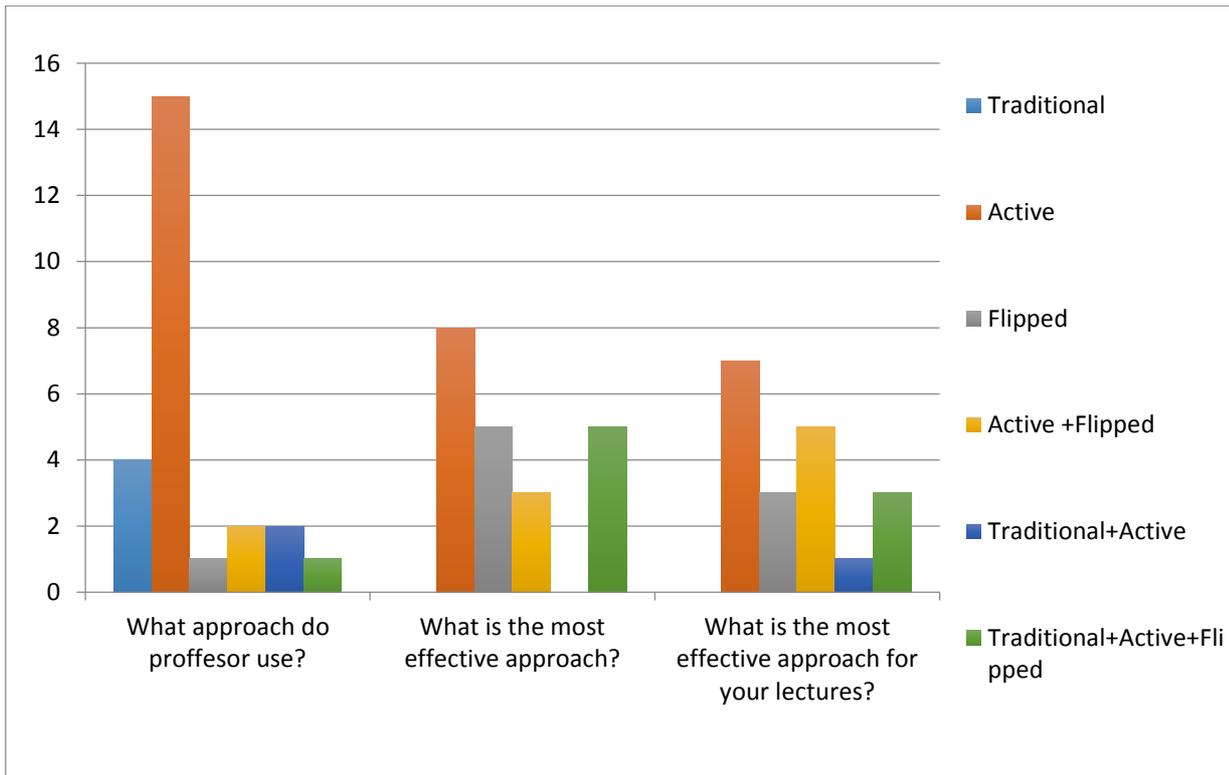
Professors also were offered to select the most effective approach and most effective applicable to heir lectures. In the table below, the most effective approach is active (32%), then goes flipped (20%) and mixes. All the mixes also contain the active component. Again for their lectures active method is the most attractive (28%). And 26 percentages choose mixes including active way. Nobody find traditional as the most effective approach in general and for

their lectures (Table 13).

**Table 14. What is the most effective approach for your lectures?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Active	7	28,0	36,8	36,8
	Flipped	3	12,0	15,8	52,6
	Active+Flipped	5	20,0	26,3	78,9
	Traditional+Active+Flipped	3	12,0	15,8	94,7
	Traditional+Active	1	4,0	5,3	100,0
Total	19	76,0	100,0		
Missing	System	6	24,0		
Total		25	100,0		

Based on factor analysis and the comparative analysis of choice of using approach, effective approach and effective regarding to each professors lectures approach are, presented below (Figure 8).

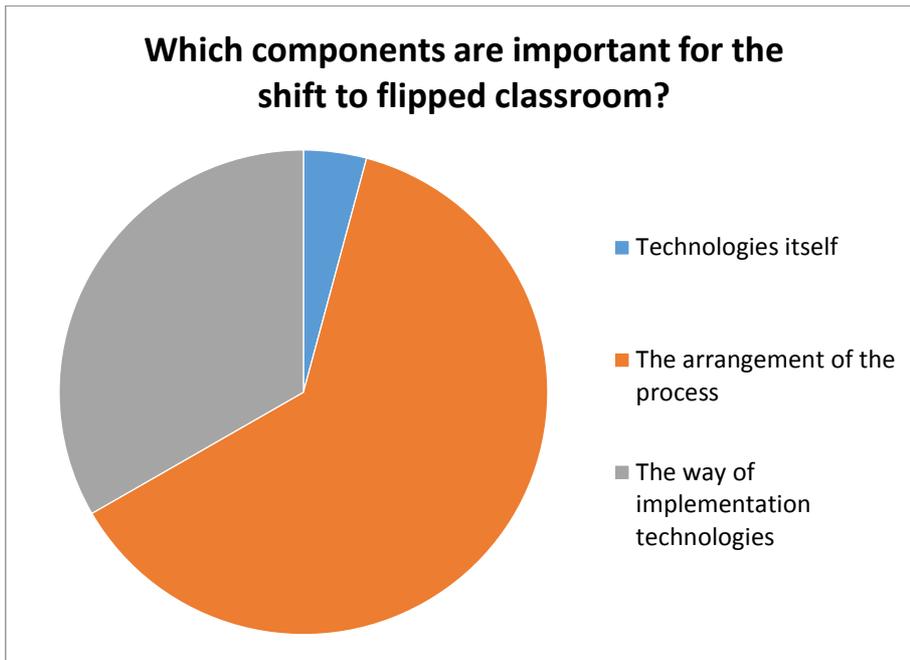


**Figure 8. Comparison analyses of approaches**

For each question active classroom takes first place. In spite of that most of the professors use active classroom, less of them suppose that it is the most effective way. Active and Traditional classroom, which are used by 4 professors was not named as an effective. Flipped classroom, oppositly is not commonly used but was found quite effective. Professors choose flipped and all the combination of flipped as effective. The distribution of valid answers can be biased due to missing values.

### 5.1.3. Shifting components and barriers for the concept

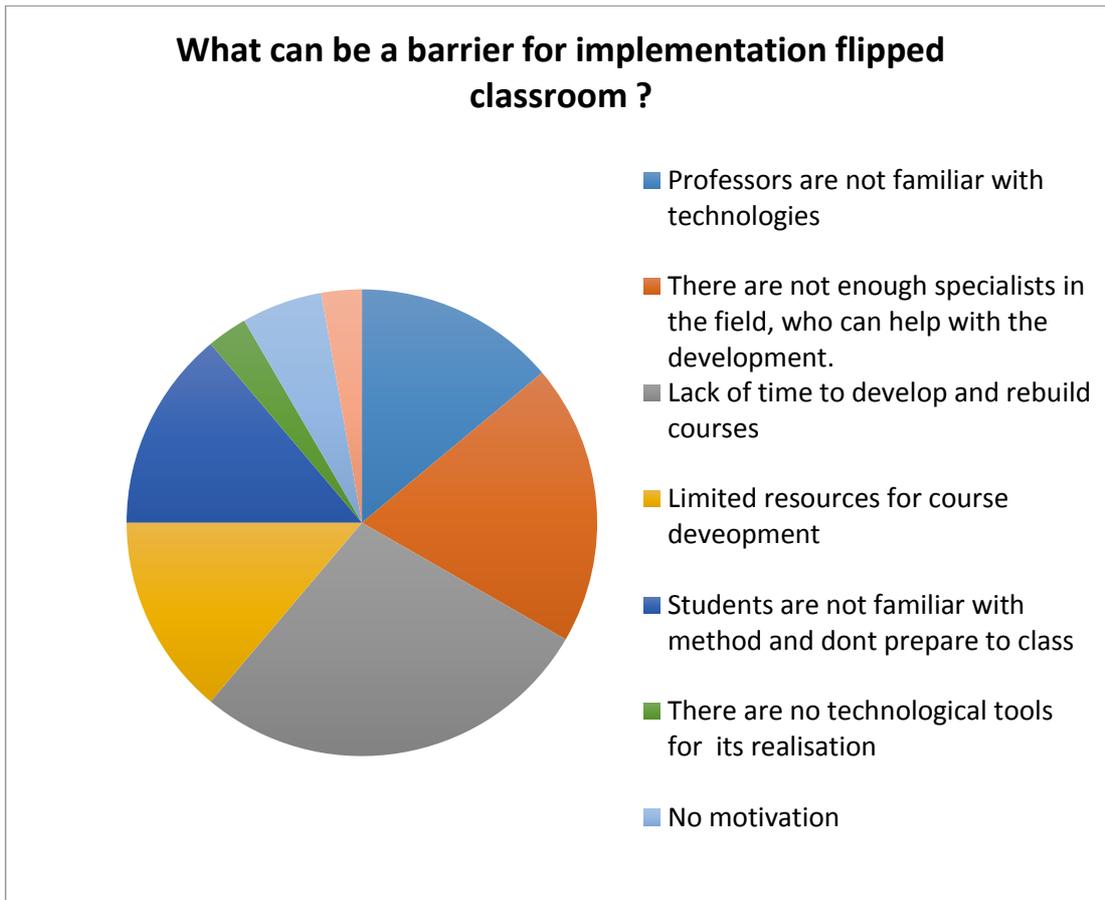
This part presents descriptive statistics for the main questions about flipped classroom implementation, components and barriers, and technologies. Components, barriers and technologies were identified based on the literature review. The Graph below shows the distribution of answers for components (Figure 9)



**Figure 9. Components to the shift**

Main part of respondents (15 people) believes that the proper arrangement of the process is important for the shift process. Approximately 1/3 of respondents support the idea that the way of implementation technologies influences the process. And only one person thinks that it is technologies itself. Professors also add the option that it is «Teachers attitude and change of mental model», possibly here it is supposed that it straight influences the arrangement of the process.

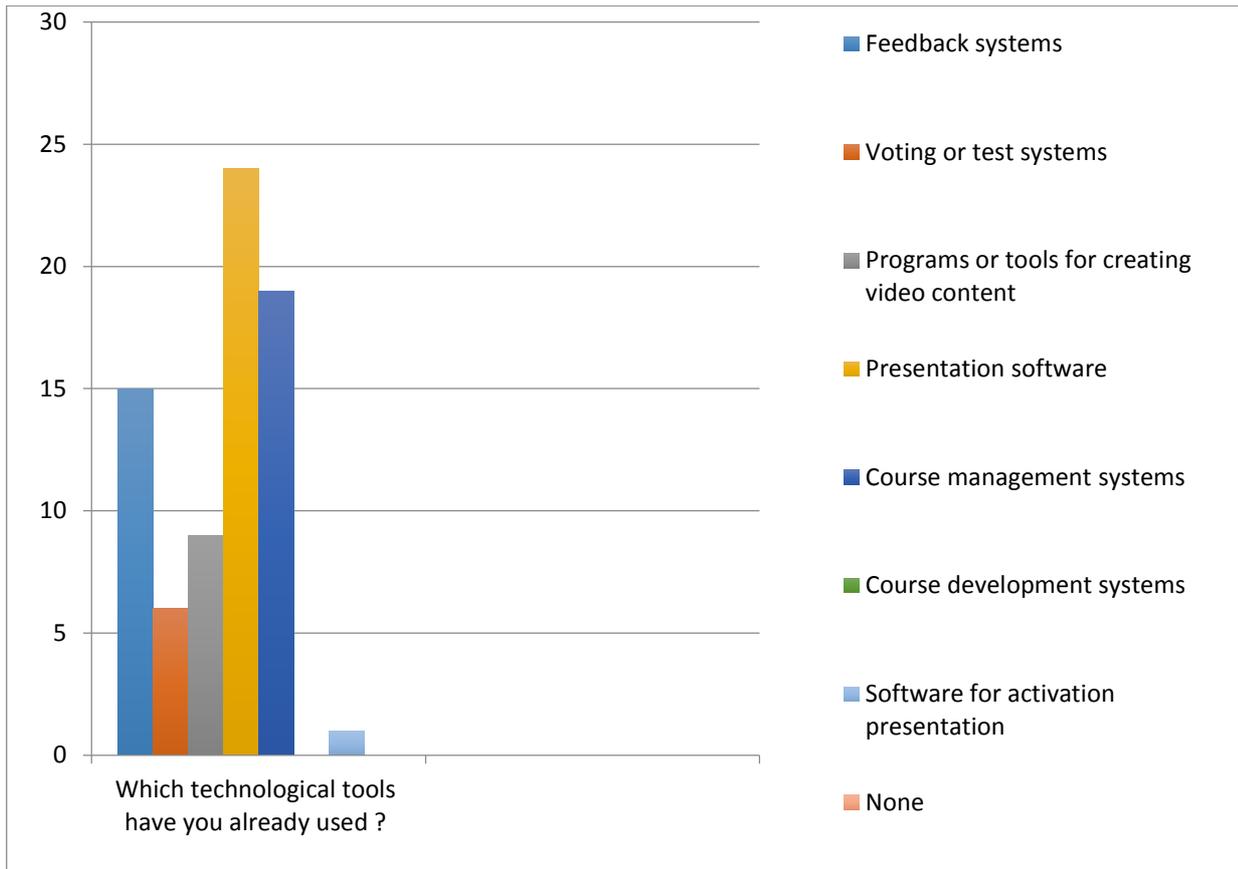
Next Figure 10 shows the main barriers for flipped classroom implementation. Lack of resources is the main barrier. Ten representatives think that lack of time (40%) and lack of resources for course development (20%) are most significant obstacles. Some professors add position about time management also. The second reason is lack of specialist (28%) who could simplify the development process. This component also can be summed with other resources and giving 56 %. The unfamiliarity of professors (20%) and students (20%) with technologies also one of the main barrier for the flipping. Positive is that practically nobody believe that there is no need, motivation or technologies for it's realisation.



**Figure 10. Barriers for flipped classroom implementation**

### **Technology and barriers for its implementation**

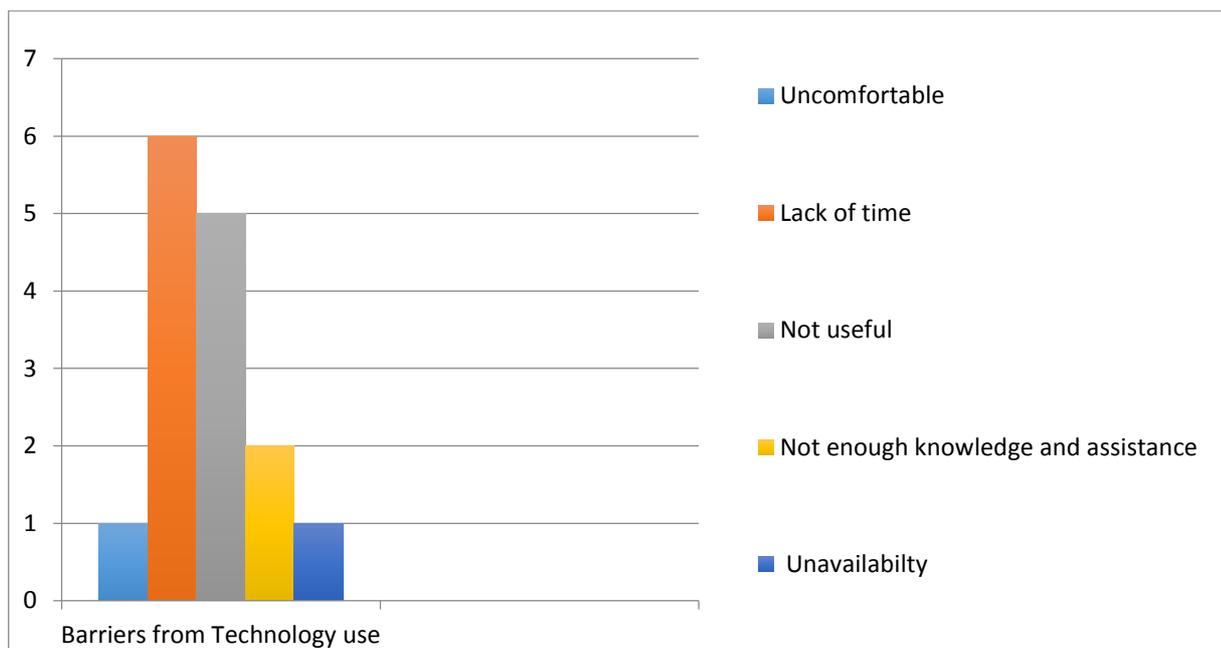
Flipped classroom implementation is impossible to realize without using technological tools. In the literature review the list technological tools for flipped classroom was gathered. Using questionnaire we can get the information about technologies used and barriers in its implementation. This information provides understanding about the way how flipping can be arranged for the professors. On the figure below technologies, which are commonly applied by professors, are presented. Figure 11.



**Figure 11. Technological tools**

As we can see in Figure 11, practically all professors are use visualization content tools like presentation (24 responses). Also the amount is high for using Course management systems such as Moodle, which become general tool for most universities (76%). However, generally nobody familiar with using course development systems as micro-adaptive and kind of new and require number of skills. More than a half of respondents use feedback systems and vote systems are also popular. Video content is in use by more than 30% percent however the lecture capture systems which create slides for video, are tried by only one person. Professors also use specific tools regarding their defined field. They were not included in the form. One professor write that he also uses «content specific tools (e.g. Strategyzer for creating interactive business model development)», another one adds about using exam aquarium, simulation game, soft wares. Additionally, two professors make an accent on using video-sharing websites like YouTube and similar content and sharing video-action links.

Next Figure presents the main barriers for technology use.



**Figure 12. Barriers in technology implementation**

More than 1/3 of professors do not see any barriers in flipped classroom implementation and try to use it as much as possible when it is suitable for the task. Respondents commented: «Technologies are nice and I'm always ready to try new technologies», «I use them as I see it fit for the task», «No specific reason, trying to implement new things as much as possible, but not every course can have everything». All the answers vary a bit, practically nobody choose the specific way of explanation with similar reasons. I categorise the answers, for 5 main reasons: uncomfortable, unuseful, unavailable, lack of knowledge, lack of time. Professors answer that mainly its not enough time (6 respondents =24%). One of them told: «I need more time for planning/preparation/getting to know these new technologies». Second group of answers focused on unusefulness (20%). Professors apply technologies with which they are used to, but have hesitation about new methods. It sometimes covered by the stated: «Lock-in in the traditional means». The third group of reasons is not enough assistance «I haven't heard enough from the possibilities how to use them». Practically nobody finds that it is enough technologies.

For the question are technologies are effective?, only two people do not give an answer and in that case with 8 percentage without answered 88 percentage believe that it is effective to use technologies and only one professor answers no.

### 5.1.3. Applicable to the course

Introduction to the next part is the question about desire to flip. Only professors, who answer yes, proceed with the questionnaire. From the statistics 3 people were excluded. Four people who choose traditional approach three of them do not want to take part in the further research. The reason why they don't take into account if do not want to flip is that they form the sample for the future flipping experiment and without their desire it can not be fully conducted. Some values are approximate and for some average values are used. For life period of their courses some professors put the time for different courses and its completely different, in that case the main courses estimated or the average value according to amount of hours in different courses is taken. In this part new variables are computed. And according to the second part of factor analysis, new revealed relations are checked.

#### **Descriptive statistics for all parameters.**

Table 15 below presents descriptive statistic for level of upgradeability of the course and invariability. The average for the upgrade level is 30% and for stay invariable is 54%.

**Table 15. Descriptive Statistics**

	N	Minimum	Maximum	Mean	Std. Deviation
How many lecturing hours do you have in a year?	18	12,00	300,00	99,5556	84,35096
How many times do you repeat the same course in a year?	20	1,00	4,00	1,2500	,71635
What is a life period of each course?	15	1,00	17,00	7,5333	4,37308
Which part of the course do you upgrade every year?	19	,07	1,00	,3068	,27757
Which part of the course stay invariable during life period?	19	,10	,85	,5447	,22230
Valid N (listwise)	13				

#### **Computed variables. Descriptives.**

**Table 16. Descriptive Statistics for computed variables**

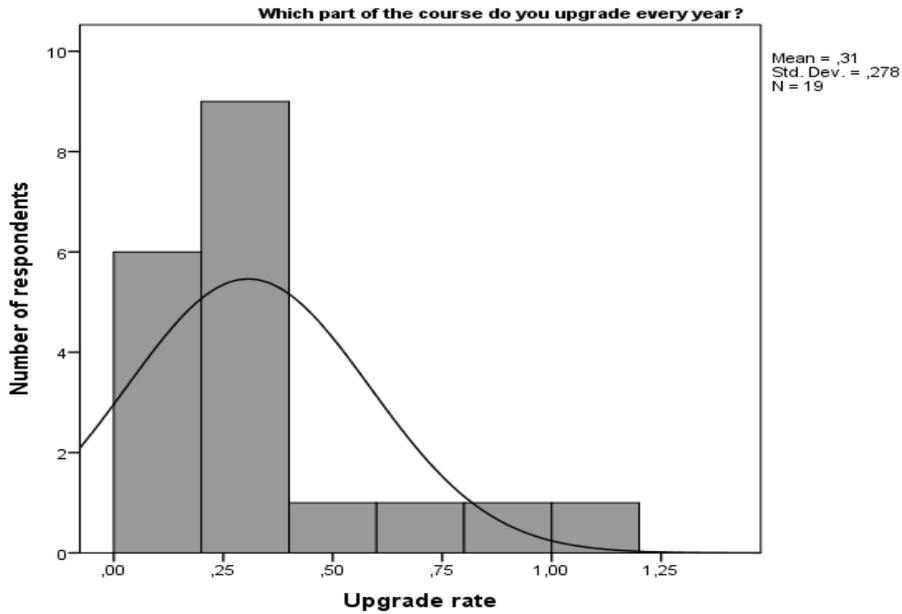
	N	Minimum	Maximum	Mean	Std. Deviation
How many hours you don't modify and repeat for all life period?	17	3,60	240,00	55,2235	64,19267
How many times do you repeat lecture in life period?	13	1,00	30,00	8,6923	7,49872
What is all lecturing time for the life period?	12	24,00	2720,00	782,0000	924,33209
What amount of lecturing hours are repeatable from all lecturing time?	12	14,40	1440,00	441,8667	490,84080
What amount of hours are modified from all lecturing time?	12	9,00	1496,00	340,1333	471,01457
Valid N (listwise)	12				

The correlation between the computed variables is the same as for the variables, as soon as they were computed from them. Special interest present means of repeatable lecturing hours (441,8667), Amount of repeats (8,9) (Table 16).

### **Correlation between Upgrade and Invariable**

The distribution of each of them showed on the graphs below.

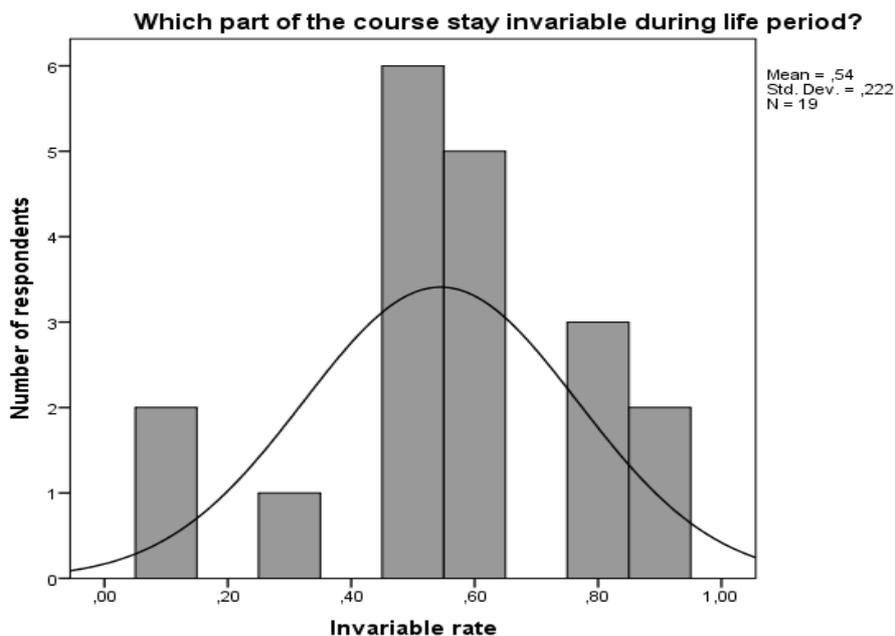
#### ***Distribution of upgrade rate***



**Figure 13. Distribution of Upgrade Rate**

According to the information, 24% percentages of respondents define the upgrade level as 20%. And Respondents who answer 30 or less compose 79% of all. And the rest of the respondents have really high upgrade rate. On the graph presented positively skewed distribution (Figure 13).

*Distribution of invariable rate*



### Figure 14. Distribution of invariable rate

The range of answers is differentiating. Most of respondents answer (16%) percentage that invariable rate is 45% and (16%) that it 60%. The amount of respondents, which has the invariable percentage less that 45%, is low nearly 35%, all other respondents don't change more than 45% of their lectures. In Figure 14 the distribution is a little bit negatively skewed distribution.

According to factor analyses the Upgrade and Invariable must be correlated. Correlation between variables presented by using bivariate correlation in the Table 17. The strong negative correlation is revealed (- 0,829). It means that the higher upgrade rate the lower the invariable rate. Using the scatter graph the relation was visualised in Figure 15.

**Table 17. Correlation between upgrade rate and invariable rate**

Correlation		Which part of the course do you upgrade every year?	Which part of the course stays invariable during life period?
Which part of the course do you upgrade every year?	Pearson Correlation	1	-,829**
	Sig. (2-tailed)		,000
	N	19	18
Which part of the course stays invariable during life period?	Pearson Correlation	-,829**	1
	Sig. (2-tailed)	,000	
	N	18	19

\*\* . Correlation is significant at the 0.01 level (2-tailed).

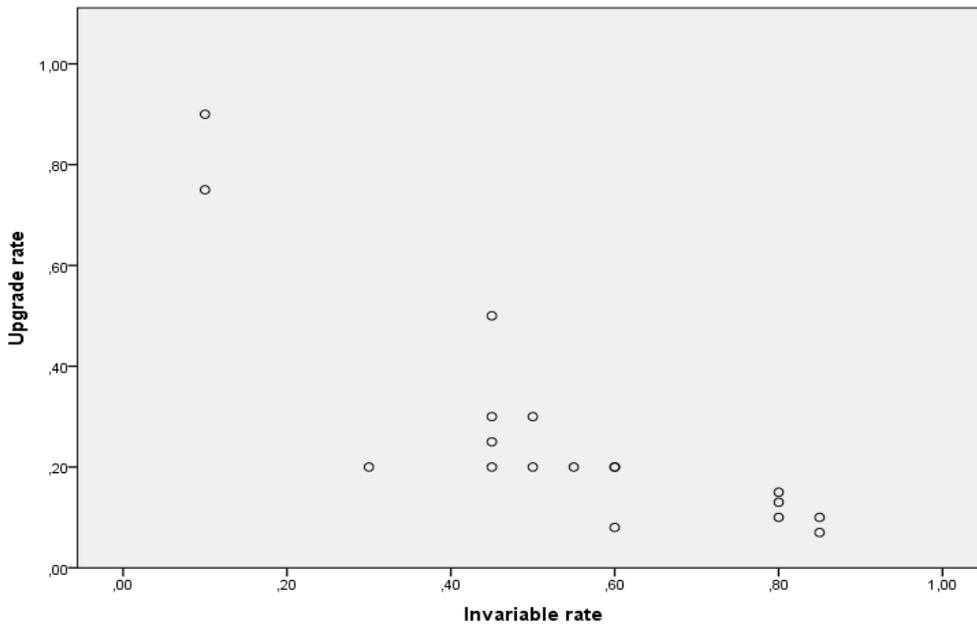


Figure 15. Correlation between upgrade rate and invariable rate

### Correlation between Life Period and Upgrade level and Invariable Rate

Descriptive statistics for life period are presented in Figure 16. The mean is 7 years and the maximum is 17 years and minimum one year. The distribution is a little bit positively skewed.

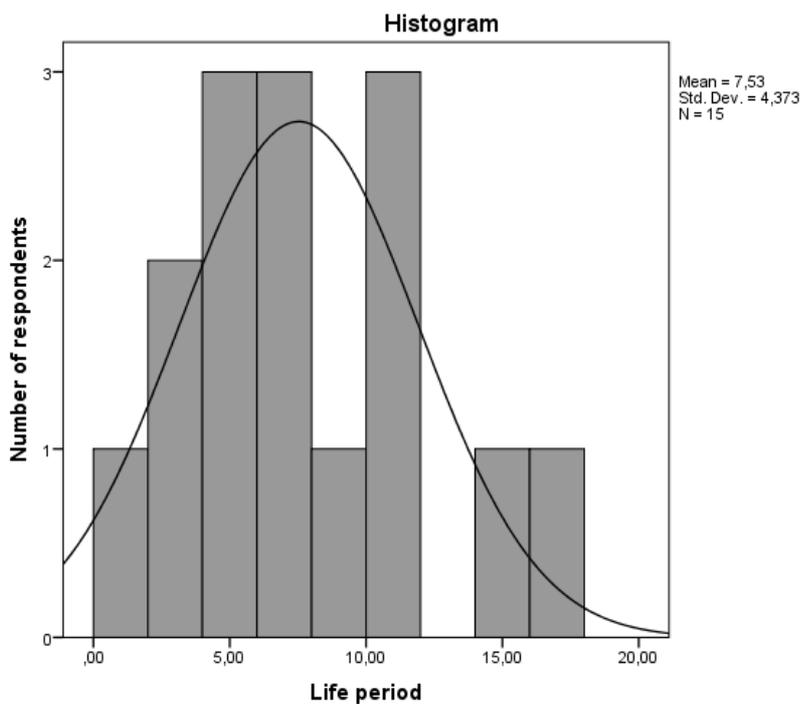
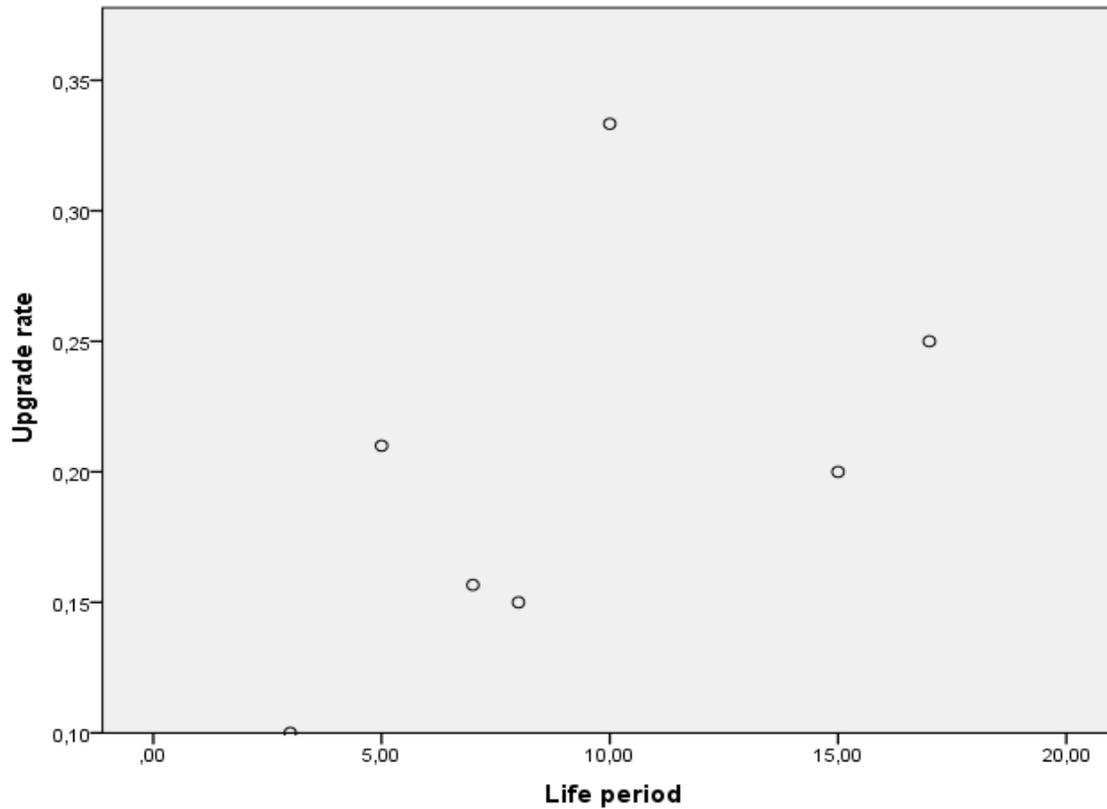


Figure 16. Distribution of life period

The table 18 below shows that correlation between Life period vs Upgrade Rate is positive and not so strong (0.389) but meaningful. If somehow observations are eliminated, it is clear that the more the life period of the course the higher the rate of upgrade.

**Table 18. Correlations between life period and upgrade rate**

		Which part of the course do you upgrade every year?	What is a life period of each course?
Which part of the course do you upgrade every year?	Pearson Correlation	1	,389
	Sig. (2-tailed)		,169
	N	19	14
What is a life period of each course?	Pearson Correlation	,389	1
	Sig. (2-tailed)	,169	
	N	14	15

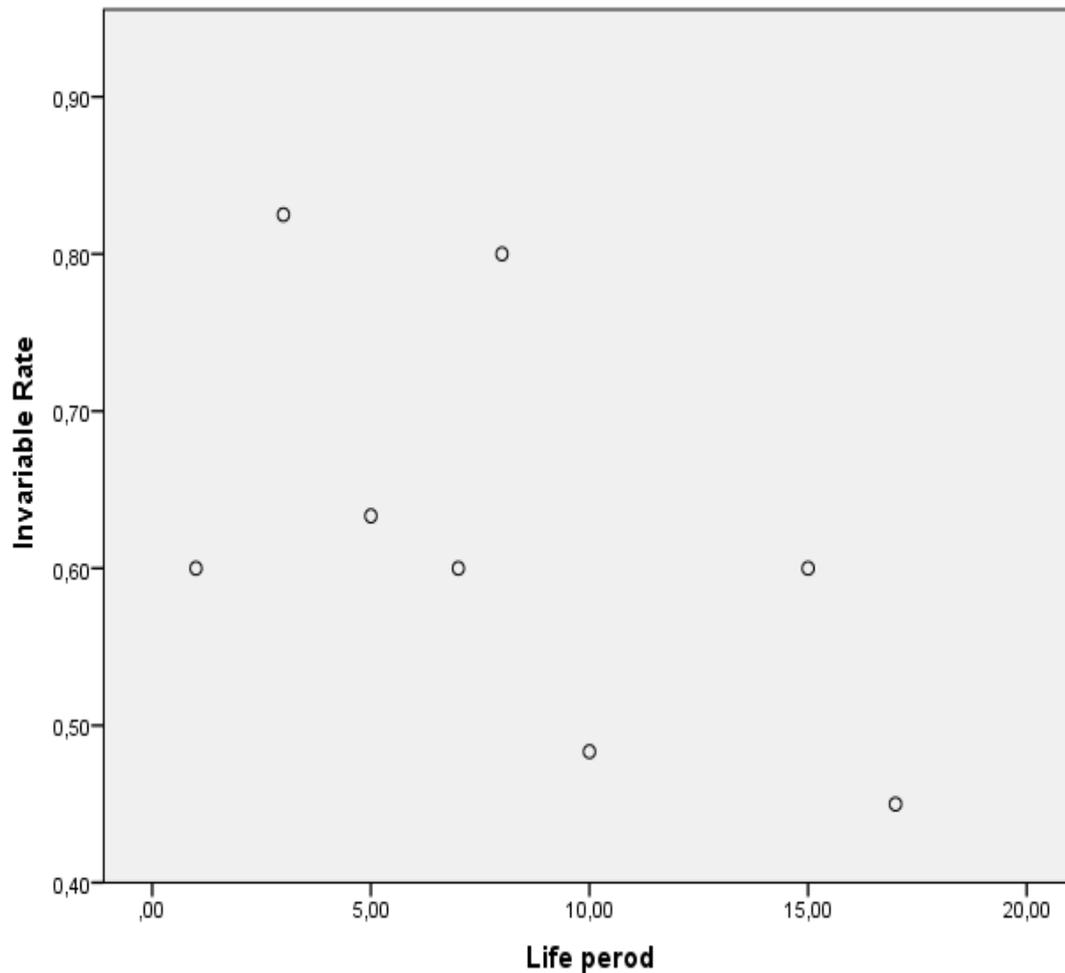


**Figure 17. Correlations between life period and upgrade rate**

According to table 19 correlations between Life Period and Invariable Percentage is negative (-0.461). It means that the more life period of the course the less invariable percentage (Figure 18).

**Table 19. Correlations between life period and invariable rate**

		What is a life period of each course?	Which part of the course stays invariable during life period?
What is a life period of each course?	Pearson Correlation	1	-,461
	Sig. (2-tailed)		,084
	N	15	15
Which part of the course stays invariable during life period?	Pearson Correlation	-,461	1
	Sig. (2-tailed)	,084	
	N	15	19



**Figure 18. Correlations between life period and invariable rate**

#### 5.1.4. One-way Anova analysis

All Anova analyses formed based on overall factor analysis between all the variables and on the qualitative answers of professors why they don't apply flipped classroom and technologies, and what components included in it. For flipped classroom the most important point is the process arrangement. Here the influence between the approach, which professor use and important part of the arrangement process as upgrade and invariable rate are assumed.

#### **Approach vs UpgradeRate. One-way**

Special interest represents finding correlation by grouping professors. First they are grouped, regarding to the approach they use. Then we try to find if the approach influences the upgrade level and invariable percentage. This research stage checks the motivation of professors, and the quality of their classes and development. As soon as we know that

correlation between upgrade level and invariable percentage already exist, it can be developed only for one of them. So the Anova developed for invariable rate.

*Question:* Is there difference in upgrade percentage for the course (and invariable percentage of lectures) for professors which apply different approaches for their lectures?

*Null Hypothesis:* There is no significant difference in invariable percentage for the course based on approach which professor use.

*Independent variable:* Approach (3 levels)

The professors were grouped to those who apply flipped (and mixes also were included), active and traditional approaches.

*Dependent variable:* Invariable Percentage

Results for the Anova are presented below.

**Table 20. Descriptives**

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Flipped	4	,4875	,29545	,14773	,0174	,9576	,10	,80
Active	12	,5167	,20151	,05817	,3886	,6447	,10	,85
Traditional	3	,7333	,16073	,09280	,3341	1,1326	,55	,85
Total	19	,5447	,22230	,05100	,4376	,6519	,10	,85

**Table 21. Test of Homogeneity of Variances**

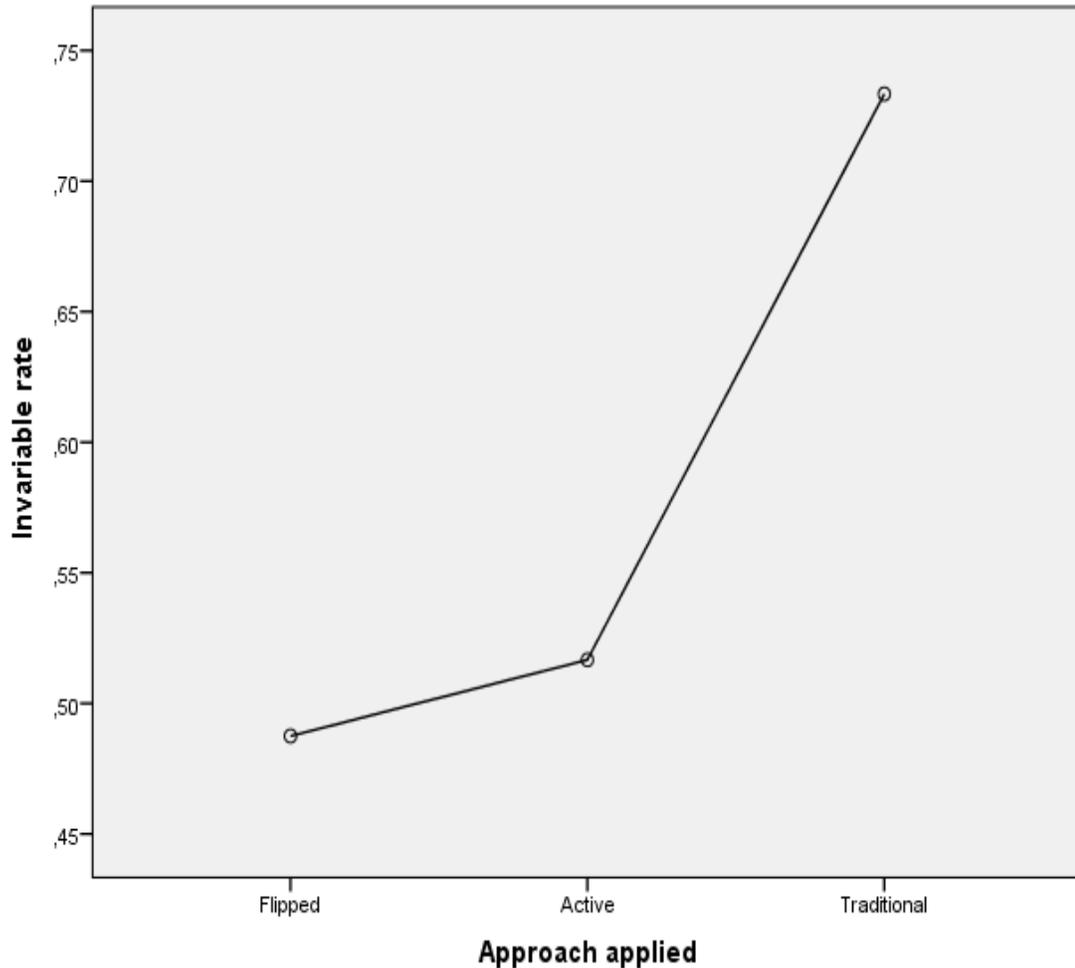
Which part of the course stays invariable during life period?

Levene Statistic	df1	df2	Sig.
,500	2	16	,616



Tukey HSD	Flipped	Active	-,02917	,12585	,971	-,3539	,2956
		Traditional	-,24583	,16648	,328	-,6754	,1837
	Active	Flipped	,02917	,12585	,971	-,2956	,3539
		Traditional	-,21667	,14070	,300	-,5797	,1464
	Traditional	Flipped	,24583	,16648	,328	-,1837	,6754
		Active	,21667	,14070	,300	-,1464	,5797
Dunnett t (2-sided) <sup>a</sup>	Flipped	Traditional	-,24583	,16648	,249	-,6434	,1517
	Active	Traditional	-,21667	,14070	,225	-,5527	,1194

a. Dunnett t-tests treat one group as a control, and compare all other groups against it.



**Figure 19. Correlation between different approaches and invariable rate**

A one-way Anova analysis of variance was conducted to evaluate the null hypothesis that there is no difference in invariable percentage of the class based on approach applied by the professor. The independent variable, approach, consists of three groups: Traditional (M=0,73 SD=0,16 n=3), Active (M=0,51 SD=0,2 n=12) and Flipped (M=0,48 SD=0,29 n=4) (Table 20). The assumption of Test of Homogeneity of Variances was tested and found tenable using Levenes tests  $F(2,16) = 0,6$   $F(2,16) = 0,5$  (Table 21). However the Anova results are insignificant  $p > 0.05$  (Table 22). And there is not significant evidence to reject the null hypothesis. Post Hoc comparison evaluates the pairwise difference among group

means and is conducted with the use of Tukey HSD test since equal variances were tenable (Alfred, 2013) (Table 23). Test reveals no significant pairwise difference between the means.

However, no significant difference in these means is found, the plot shows the significant difference in means (Figure 19). Here it is clear that professor who apply flipped classroom has less than 50% invariable rate and for active it is little bit more but for traditional it is completely higher approximately 75 %. And the actual difference in the mean scores between groups was meaningful. This effect size is Sum of squares between groups/ total = (0,14) based on Conens conventions for interpreting effect size.

#### 5.1.5. Desire to flip

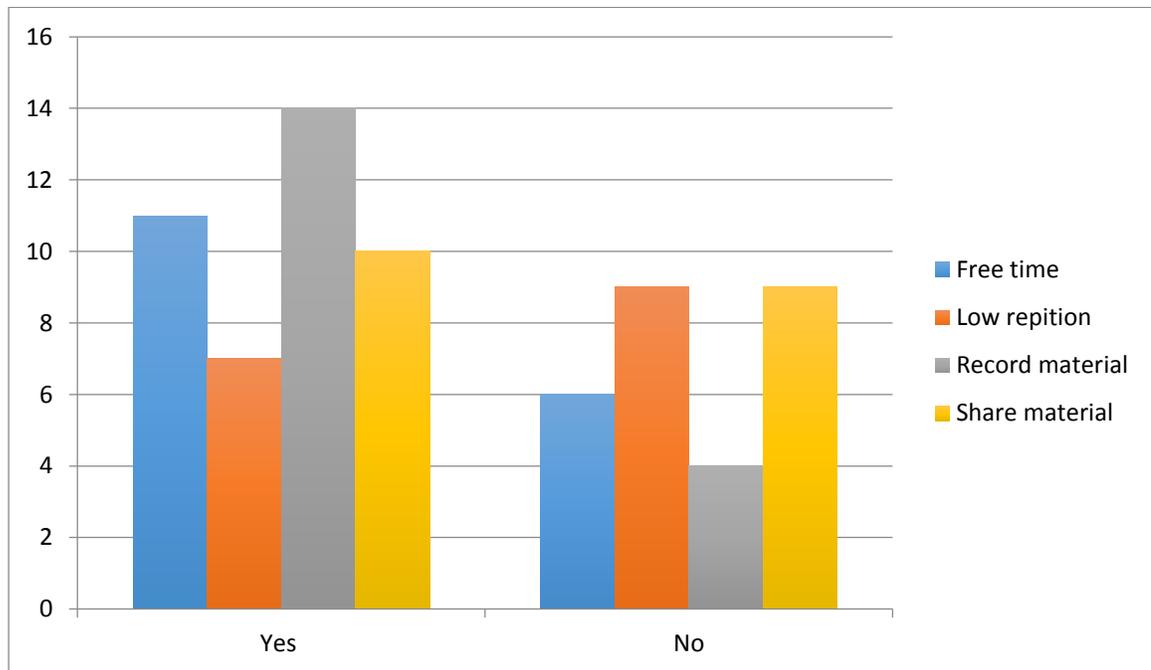
Desire of the professors influences their further participation in the questionnaire. If they answer no the questionnaire form is closed. The professors who answer yes can further fill in information about their courses. During the questionnaire more than 75% percentage of professors answered that they would like to flip.

**Table 24. Do you want to implement flipped classroom?**

	Frequency	Percent	Valid Percent	Cumulative Percent
V No	4	16,0	16,0	16,0
ali Yes	19	76,0	76,0	92,0
d No answer,but continue	2	8,0	8,0	100,0
Total	25	100,0	100,0	

Moreover the desire related to flipping is illustrated by figure 20 below. Approximately 80% would like to record material and other reject this idea. More than 60 % would like to free time. A little bit more than a half would like to share material. More than 57 % don't

want to low repetitions. As soon as the correlation between all these parameters can be revealed through the figure above it should not require to do additional bivariate correlations and graphs.



**Figure 20. Computed variables. Descriptive statistics.**

## 5.2. Experiment

### 5.2.1. Experiment 1

This experiment presents a description of a practical implementation of TRIZ concept for the course in the faculty of Industrial Engineering and Management in Lappeenranta University of Technology (LUT). The professor initiated and desired to visualize part of his material. With the professor already we choose the means of visualisation.

According to the professor's requirements, the plan was to record part of the TRIZ course

«Ideal Final Result» and number of examples. Four main designs were estimated to find the appropriate one for the experiment.

1. Record the audio and add visualisation

Using this design the content with the voice of professor can be developed. The main advantage here is that professors can easily record it independently and connect with presentation or with other material. The main disadvantage is lack of personalisation of content. As far as professor's presence influences on a listener by him/her authority.

2. Record the video and add visualization

This stage differs from previous by adding video of professor, which can be edited and mixed with other information.

3. Record the video and add it in the CMS /CDS

Previous two stages have one more disadvantage as lack of activation and adaptation. And this stage with adding videos in CMS gives more interaction to students by adding other materials there, like tests.

4. Developed in LCS content

For this case, already existed slides are connected with video made by professor using a webcam. This stage is simple in realisation and creates similar to the lecture-class environment. In addition all the material can be shared openly. To make LCS content more adaptable it can be introduced in CMS and adapted by adding tests.

According to the main requirements such as: personal presence of the professor on video, implementing the video in Moodle course management system, ease and ability to record anywhere, convenience for the professor, person who assists with development process, the third variant was assigned.

The videos was developed using the phone, the atmosphere was comfortable as a coffee-break, the video was edited by a basic program without the professor. All the videos were

recorded and edited by the author of the thesis, who has no any previous experience in it. During the work main activities were:

- 1) Assign the meeting of professor with developer (here I developed the content)
- 2) Record videos during the meeting
- 3) Discuss what can be edited changed or added
- 4) Edit video
- 5) Send video to professor to test and approve
- 6) Insert video in a CMS system and share it openly

In the CMS system two scenarios are constructed. For example, students try to do example by themselves and attach the answers after that watch the video and verify their understanding, leaving for the class just remained gaps. In the case with introduction video fragment first the student watches video then goes through tests to clarify the understanding and than answer additional questions in the class. Both of these two scenarios were approached for the flipped classroom preparation for the class part in Moodle.

The recording meeting and editing time were counted and presented further. However the numbers cannot be accurate thus formed results give approximate values. During four meetings 63 minutes of video were recorded. First meeting -10 minutes, second -27 minutes, third -14, fourth-12 minutes. And the develop content consists mainly of three first videos The time was also spent on discussions, which was approximately 15 minutes. In the result of our work 7 edited final videos were developed, one introduction video and 6 example videos. Core video for the topic contains 13 minutes and six examples with total duration of 29 minutes, in sum 42 minutes. Finally from 63 minutes in progress 42 minutes of material were recorded. With omitting 21 minutes due to no need or repeating. Practically, 3 to 4 hours were spent on rearranging of each short example video and 10 hours on the first long video as soon as it was first experience in video development. In sum it is approximately 30 hours of work load. And it is estimated that one example inserted in 3

minutes video would take 9 minutes in class. As soon as the professor named 3 as a compressibility level of video comparison to the class. If we suppose that the video cuts the in class time 3 times it means that 42 minutes of material would require 120 minutes in a class. Practically, 80 minutes decrease, which cover 63 minutes on recording.

In Table 25 values for the resource-effectiveness are presented.

**Table 25. Variables for the experiment**

Variable	Description	Formula	Value
Recording time	The time spent on recording	No formula	63 minutes
Video time	The developed video time	No formula	42 minutes (Pure material= 35%)
Approximate discussion	Discussion for one meeting	No formula	15 min
Amount of meetings	Amount of meeting professor developer	No formula	4 meeting
Discussion time	Time during which prepare and discuss	=Approximate discussion* Amount of meetings	60 min
Time professor developer	Time spent with professor and developer	Recording+ Discussion time	123 minutes
Extra time	Extra time which professor spend with developer	= Time professor developer-Video time	81 minutes =65%
Compressi	The rate of time in	The professor proves this value	3 times

bility of material	class and video time for the same material.		
Time in class	Time, which is required in class for the same material	Video time * Compressibility of material	126 minutes
Time for developing	All the time which need to develop the content	No formula	30 hours 1800 minutes
Time for developing 1 minute	Time which is spend on developing one minute	Time for developing/ Video time	40 minutes
Repetitions	Amount of times professor repeats this material for all the life period of the course	The professor proves this value	20 times
Resource effectiveness 1	Amount of time spend in class for mines amount of time for development of content	$=(\text{Time in class} * \text{Repetitions}) - \text{Time developer professor} - \text{Time for developing}$	597 minutes= 9,95 for 42 minutes
Save 1	Amount of time which can be saved by recording	$= \text{Resource effectiveness} / \text{Video time.}$	14 minutes by recording 1 minute
Resource effectiveness 2	Amount of time spend in class for mines amount of time for development of content (with outsourcing)	$=(\text{Time in class} * \text{Repetitions}) - \text{Time spent by professor}$	2397 minutes = 39,95 hours for 42 minutes

Save 2	Amount of time which can be saved by recording	Resource effectiveness / Video time.	57 minutes by recording 1 minute
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Some values from Table 25 of them are gained during recording and developing, some of them given by the professor and some are computed. «Time developer professor» practically equal to the «Time in class». The value for compressibility of material means that professor spends less or same time for developing than in class. And for students it means that they get more compressed video materials and more adapted, because inserted in the CMS. One lecture can cover the time for recording and discussing video. It is possible as soon as developing of other content is outsourced to other person. The professor gives the repetition rate, however from the questionnaire the average value of repetition rate is 10 times. It is individual to a professor and can vary according to the material recorded. There is material, which really important in lecture and it can require higher repetition rate and thus should be recorded.

Resource effectiveness is computed by multiplying «Time in class» and “Repetitions” mines “Time developer professor” and «Time for developing» of video if the professor does it. There can be two different variants and two different results. The «resource effectiveness 1» is counted according to the case that professor is a developer itself and aimed show the cut of 14 minutes from 1 minute video time in the future. For the «resource effectiveness 2» time for development is excluded as it is outsourced and it saves 4 times more time. It can be deduced that editing the video takes the largest amount of time. In both cases, this method is resource effective and saves a lot of time for the professor. By using one full conducted experiment, it can be concluded that resource effectiveness of the method proved. Also the results for the amount of repeats to other professors are compared and with the repeating amounts like 10 it also give beneficial results for the resource effectiveness 2. Also it just one approach checked, but this one is not the less resource required than for

example LCS or just video recording.

### 5.2.2. Experiment 2

Second experiment reproduces the active part of the flipped classroom. During it the originally developed feedback system was implemented. The feedback system «AskBox» allows listeners during the lecture to give notes and ask questions to the professor using their own devices, without interruptions. The additional window for the program can be realised above the presentation (Figure 21, 22). The steps of program development were:

- 1) Develop the 1<sup>st</sup> prototype (2012);
- 2) Develop the 2<sup>nd</sup> prototype (2013);
- 3) Gather the team and take part in Microsoft Competition
- 4) Develop the 3<sup>rd</sup> prototype
- 5) Test in summer school in LUT

The system was applied for the number of lectures. The main idea is to increase interaction between student and professor. This system allows not only to answer the professors questions, but also to initiate the communication to student. It is possible to do anonymously. The system allows not just to make answers but to initiate the communication using it.

Experiment was successfully conducted in the TRIZ course in Summer school 2015 in LUT. The professor with personal assistance of the author of the thesis applied the program during the class. The program raised a huge interest and it can be supposed that first distracted student's attention from the lecture. However, then students got used to the program, they started to use it for the lecture needs mostly. The professor also was really interested to get the feedback for his class. The professor felt comfortable after the first use with assistance

and felt that could apply it by himself in the future.

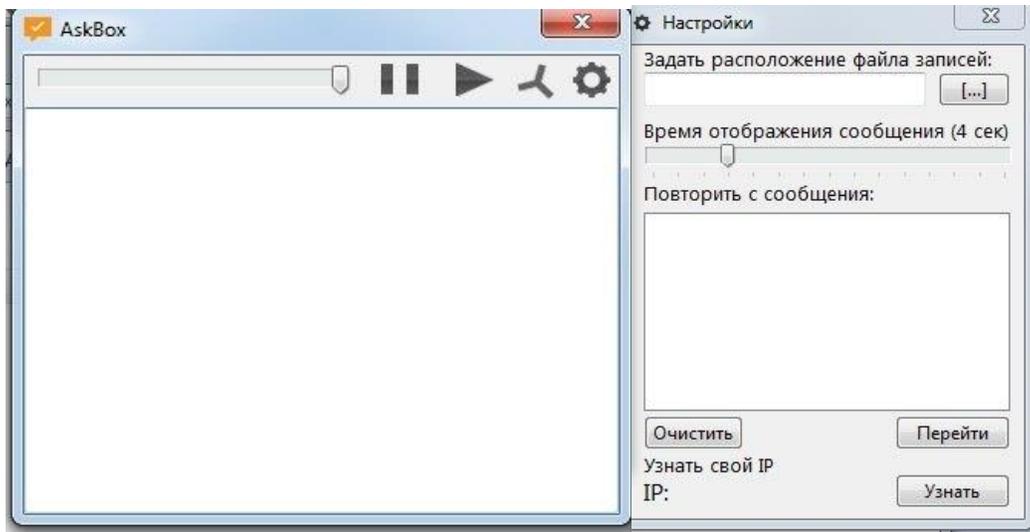


Figure 21. Program window

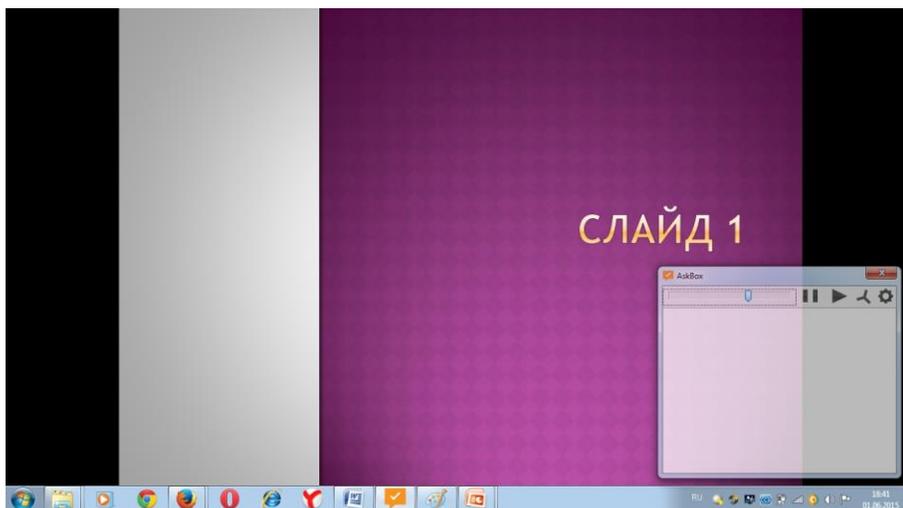


Figure 22. The presentation window with the launched program

## 6. Discussion of the results

The main aims of the thesis are achieved. First of all, literature review part presents the evolution categorization of different blended methods in education, including flipped classroom. Moreover, the approximate categorization of technological tools applied to the flipped classroom is included. Secondly, the applicability of the concept studied in questionnaires. And exact percentage of professors who can apply the concept and the spreading of desire were deduced. Third, not only the decline of the resources was proved, but in the experiment exact tenable values are counted.

### 6.1. Approaches and their effectiveness

According to the questionnaire results, it can be concluded that professors now are mainly focused on active methods, are used to them and work with them. Some of them use mixes but make an accent on the activation of the class. The professors choice about the most effective in general and most effective for their lectures is also focused on the active way. One of professors told: «Hard to say without practical experience of all methods. Intuitively, any method that keep students active and participatory would work». In comparative analysis of approaches used and most effective, the professors rate flipped classroom as a more effective method in general but less for their own lectures. Their tendency to activate class and some kind of avoidance to flip can be explained by not full awareness about the inverted approach or challenges conveying its implementation. Possibly, they are not fully appreciating that there is just one step from active classroom to flipped one. Inverted classroom already includes activities. And just preparation part before class is missed. The revealed low rates of familiarity with approach present a field of study and application. Perspectiveness and success of the concept were already proved in the literature review. It gives a base to future discussion about flipped classroom implementation with professors who are not familiar with the idea.

Finally, most of the professors find that the inverted classroom concept is effective. So the main recommendation here is to raise professor's awareness of the flipping method, demonstrate it in the real life, how it works and which beneficial results it can bring. The

clear understanding supports the tendency to apply and find the appropriate way for professors.

## 6.2. Implementation

### 6.2.1. Components Barriers and Technologies

Recommendations about flipped classroom implementation are formed based on barriers, components and technologies, which should be avoided or overcome. To answer the sub-question 2 and form the instruction for flipping first all the recommendations should be gathered.

In case of existing need and desire to flip, shift to inverted classroom can be stimulated by a proper application of a number of components and main of them are: arrangement of process, implementation of technologies, type of technologies. Teachers agree that it is not only technologies but how they are implemented (Tucker, 2012). For example, students cannot just watch videos and that is why they need to proceed working with it, so the professor should create the whole environment (Bergmann, 2012). The statistical results in questionnaire prove that fact.

To overcome the barriers during the implementation, it is important to find time and labour resources (specialists), which can maintain and support part of the work, as soon as main barriers for flipped classroom implementation and technology implementation also is lack of resources. The fact of the lack of time means that they don't find that the use of new methods can rise efficiency and actually save their time and bring better and faster understanding to students. To avoid struggle between technologies (Tucker, 2012) and professors and reduce challenges for professors to work with technologies one could find specialists who could familiarise professors with technologies or outsource this process. In both cases, additional resources (time) from the professors are not required. After the first time struggling with the lack of different resources, professors will be more motivated to apply the concept in the future. It is proved by the professors already «It is always too difficult to start to use because you have to learn new here can be a reason of no time to

learn and no assistance to help». Moreover the experiment 2 shows that it is easier for professor to apply tools after first time doing it with assistance. Especially if their experience bring cut in the resources, as supposed in this research. Time and assistance can be interchangeable. More assistance decreases the time spending on cognition. Alongside with that, more time given professors for learning tools by themselves, eliminate the assistance need.

The concern about student's unfamiliarity with technologies is not really proved. Definitely, some students are more satisfied and some not but mostly their level of adaptation is higher than professors one. The use of technologies in everyday life watching videos and getting the information that way maintains it. Growing amount of open free sources can reproduce possible lack of technological tools in the university. For example, video can be developed easily on any camera and content can be developed using free editor or creator, LCS slides. Moreover visualized content doesn't always means the video, it can be course part of defined material. The answer about no evidence that FC improves student knowledge more than traditional, proves the fact that professors are still not really sure about the concept. It was already clear, that the percentage of unfamiliar is high, so the solution to familiarize professors with the concept and its effects is the first step.

There is a huge range of different technological video methods, but professors are not familiar with them. For the flipped classroom special interest represents activation part of class and video/course preparation part. The spreading of answers for technologies shows that representatives are familiar with interactive technologies of process. Low rates for the video tools use show that they are not so familiar with huge variety of video creating technologies. Especially with new and more effective online micro-adaptive systems developed technologies. It can be concluded that professors are not familiar with new technologies and do not follow them so much. However, in general the results are not fully negative as soon as there is no one answer like don't use technologies itself or don't want to use or don't find them useful.

### 6.2.2. Desire to Flip

To answer the sub-question 1, the percent of respondents, who would like to flip, was measured. More than 70% can and would like to flip their classes and this is rather good number and in comparison with that fact that more than 70% never tried the concept.

Besides, the professors were asked about their desire to record material, to save time, to lower repetition and desire to share their materials openly. Each of those points can give more benefits for professors. Recording the material allows creating video with their personal participation. Sharing openly allows creating the material for in-class studies and distance courses, like in case with MOOCs, which also use openly on the platform and alongside with that in class in defined University. Instead of fully implementing flipped classroom, the professors want to use just a part of its advantages.

Different spreading of desires allows defining the more appropriate strategy for flipping for the professors, regarding to the sub-question 4. For high percentage of professors, who desire to record it is possible to use all the methods for producing videos, for the rest more appropriate will be to develop the audio or course content or using shared by someone else videos from YouTube. It is possible to mix flipped classroom with the distance classes. Or just publish the materials and gain more advantages.

The main significance is represented by the desire to lower repetition and save the time. However, there is a low percentage of professors who would like to lower repetition. These values can be noticed but not fully appreciated that flipped classroom gives this advantages. And practically it is not clear why only 60% would like to save the time, while calling it the main barrier for flipped classroom implementation.

### 6.2.3. Applicability of the concept

Possibility to apply the concept can be illustrated by the numbers which characterize their courses: amount of hours, lecturing time, upgrade course rate and invariable course rate, repetition rate and other computed variables. The inappropriate courses with low level of

repetition, low level of invariable rate, high upgrade rate and short life period which are not allow applying the concept at least for a part of lecture were not defined. Oppositely to that, the amount of lecturing hours is long - 100 hours, the average value for a repetition rate is 1,2 in a year and with a life period mean 7,5 years it is quite enough for flipping. The upgrade percentage is 30%. The invariable percentage not so high 54% .All these mean that there is a great potential for inverting.

Aim to achieve is to increase the upgrade level and low invariable percentage. Correlation scatter plot between these two variables shows that the ideal variants presented only by the number of professors, who has really high percentages of upgrade like 80 and low invariable percentages like 10. Using the Anova analysis the correlation between approach used and invariable level was provided. According to the resultssignificant influence of type of approach on invariable rate was not revealed. Possibly because of low amount of respondents. However the difference was significant for professors who use flipped classroom approach, invariable percentage is lower. And for active it is higher and for traditional is really high. Professors who already choose flipped classroom break up the statistics.

The field of the professor was checked and its dependence on the approach applied as soon there were no significant results and differences for active and flipped classroom. However, the plot shows that proffesors who apply traditional way have more lecturing hours. Possibly it can somehow prove the existence of the barrier of lack of resources (time) for implementing a new approach.

One more positive tendency was revealed. The more life period the more upgrade rate, it is a positive tendency, which should be stable. And for invariable rate it is opposite: the more life period of course the less invariable percentage. These two tendencies signify the good results.

#### 6.2.4. Instuction

Based on the obtained results we offer a generic instruction for implementation of the

flipped classroom.

- 1) Familiarize with approach;
- 2) Familiarize with success of approach /Prove the effectiveness;
- 3) Help with implementing;

In the experiment 2 it was conducted and proved that developer eases the professor life and helps substantially.

- 4) Prove the resource effectiveness in practice.

### 6.3. Resource effectiveness

Literature review, questionnaire and experiments help to finally check the main hypothesis for this research which states that the flipped classroom is a long-term perspective concept, which implementation cuts the lecturing owing to declining amount of repeats. The literature review revises all the reasons why this concept is not a short-time tendency and with a strong possibility the scale of its implementation will be increased. Due to the questionnaire high repetition level was revealed in a life period for the course and most of the professors desire to lower rate and to save the time. The existing problem was solved in the first experiment, where the decrease of time for the future was clarified from flipping, concrete in this cases, recording part of the material. The experiment with professor shows the save of 15 minutes for the future from the recording of each minute. Definitely, these results are approximate and must be individual for each professor and technologies and methods which are used for flipping. The prove base for this theory is also a little number of literature sources that proves some cut of resources and increase of effectiveness of flipped classroom for learning process, which give an answer for sub-question 3 and loss-free in quality. Finally, it can be concluded, that appropriate flipped classroom implementation can decrease amount of repeats and save time, professor efforts and occupied space for the class

without loss of quality of education.

## **7. Conclusions**

This research contributes mainly to the educational field expanding the knowledge about blended learning approach «flipped classroom». It summarizes its main effects on students and their learning performance from the previous literature and investigates professors' attitude to, awareness and applicability of the flipped classroom by means of questionnaires and field experiments. Main findings suggest that flipped classroom being exceptional learning experience for students is appealing teaching approach for most of participated professors as well. Though its implementation faces some barriers, it can be facilitated by increasing awareness of this concept among teaching staff and arranging support in material preparation for the lessons. The study reveals future perspectives of the concept based on the scale of its use and existing results.

This research creates a solid background for further perspective elaboration and mass implementation of the flipped classroom concept in LUT, SPbPU, and other universities around the globe. Continuation of the research and rising familiarity of professors with the concept as well as conducting more experiments in order to polish implementation strategy are important directions for the further research.

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