OPEN ACCESS

EURASIA Journal of Mathematics Science and Technology Education
ISSN: 1305-8223 (online) 1305-8215 (print)
2017 13(8):4831-4845
DOI: 10.12973/eurasia.2017.00967a

Systematic Review and Results of the Experiment of a Flipped Learning Model for the Courses of Descriptive Geometry, Engineering and Computer Graphics, Computer Geometry

Marianna V. Voronina
Saint-Petersburg Mining University, Russia

Olga N. Moroz
Saint-Petersburg Mining University, Russia

Alexander E. Sudarikov
Saint-Petersburg Mining University, Russia

Mira B. Rakhimzhanova
L.N. Gumilyov Eurasian National University, Kazakhstan

Eduard Kh. Muratbakeev
Saint-Petersburg Mining University, Russia

Received 17 March 2017 ▪ Revised 20 June 2017 ▪ Accepted 13 July 2017

ABSTRACT

The relevance of this study is determined by complete absence of serious research in the use of flipped learning model (FLM) in teaching students of engineering universities Descriptive Geometry, Engineering and Computer Graphics, Computer Geometry (DGECGCG); by the absence of scientifically-based, tried and tested programs and teaching materials for flipped DGECGCG learning; as well as by the need for the development of new, modern tools to support classroom work and forms of students' individual work. The purpose of the study is to examine the current state of knowledge and practice of existing DGECGCG courses, using the "flipped" concept as the main pedagogical strategy. Research methods of the issues were: pedagogical experiment, expert assessment (individual and collective) and cluster analysis (Euclidean distance, squared Euclidean distance, Ward's clustering methods). The experiment involved 25 first-year students of Electromechanical and Mining faculties and 4 lecturers of the Department of Descriptive Geometry and Graphics of the Saint Petersburg Mining University. The results showed that since 2012, flipped learning has gained popularity not only among school teachers, but among professors of engineering universities. This article represents a synthesis of qualitative and quantitative researches of flipped learning models in the field of engineering education; students' attitude towards flipped learning, the role of teaching materials as well as the role of professor's personality have been identified. Advantages and disadvantages of this learning model have been revealed. The study proved the absence of scientifically-based and tried and tested programs and instructional materials for teaching students DGECGCG using FLM. The need of further scientific researches of flipped DGECGCG learning models has been identified. Recommendations for training students have been provided. The materials of the article can be useful for Professors in the field of engineering.

Correspondence: Marianna V. Voronina, *Department of Descriptive Geometry and Graphics, Saint-Petersburg Mining University, Saint Petersburg, Russia.*
maria.vv@mail.ru

State of the literature

- Since 2012, the FLM approach has gained increasing popularity not only in schools but also in engineering universities, particularly in STEM fields.
- FLM creates opportunities for solutions of complex pedagogical problems in engineering education, but creates some difficulties in preparing for the implementation of the model.
- Most of the researches in the field of engineering education based on the FLM have been conducted on the basis of short-term studies, and on feedback from professors and students and their reviews.

Contribution of this paper to the literature

- The synthesis of qualitative and quantitative researches of engineering courses that use a FLM.
- The study showed that the issues of DGECGCG FLM have not been investigated in the scientific and methodological literature.
- Students' attitude to FLM, to the role of teaching materials as well as to the role of professor's personality in FLM have been identified.
- Advantages, disadvantages of DGECGCG FLM and recommendations on training of students have been provided.
- To create reasonable theoretical bases of pedagogy in the field of DGECGCG FLM as well as methods of evaluation, it is necessary to conduct further scientific researches examining various aspects of the practical implementation of long-term, tried and tested programs and instructional materials for teaching students.

Keywords: descriptive geometry, engineering and computer graphics, computer geometry (DGECGCG), flipped (inverted) learning model (FLM), teaching materials, science, technology, engineering and mathematics programs (STEM)

INTRODUCTION

The urgency of the problem

Education systems all over the world are reforming as a result of global changes in society, transformation of political systems and other socio-economic factors. The essence of managing the development of higher education system is to increase controllability and productivity of higher education system from the point of view of methodological, organizational, content and technological change, leading to opportunities to develop positive education reform and to reduce its negative impacts (Levina et al., 2016; Cai et al., 2017).

Previously, engineering education was mostly a supporter of traditional pedagogical approaches. However, recent revolutionary advances in information technology; the broad-scale development of Internet technology has opened completely new areas of researches in the field of education. Today's competitive global market and changing work environment demand that engineers possess «soft skills» in addition to technical skills, and they must be able to understand project goals and have the ability to accomplish them with available resources. Currently, engineers learn leadership and management skills while working - learning «soft skills the hard way». In order to meet the demands of this changing world, engineering programs are challenged to come up with innovative ways of learning, so that graduates are prepared to take on the challenges twenty-first century engineers face (Kumar & Hsiao, 2007). Researchers should constantly think of new ways to improve existing theories and models of learning styles, develop and implement new learning technologies, comparing practical experience with modern learning models.

It should be noted that the world view of today's youth changes with the development of information technology. Many pupils and students are able to successfully perceive the information not only being inside the classroom but outside the classroom, using a variety of information devices (Boudet & Talón, 2012). In addition, individuals are known to have their unique learning styles as well as their own perceptual speed. For these reasons, in order to form students' expertise in acquiring and applying new information and skills, the process of engineering education is being constantly rethought in order to improve students' educational results, to select and justify the application of educational technologies.

We reviewed and presented the traditional model of teaching students DGECG in the works of M. V. Voronina et al. (2016), M.V. Voronina & A. I. Folomkin (2017), M. V. Voronina & E. Kh. Muratbakeev (2017), M. V. Voronina & E. V. Simenko (2017), M. V. Voronina & Z. O. Tretyakova (2017), P. M. Gorev, & A. M. Kalimullin (2017). The article describes the principles that should be considered into large-scale Foresight researches of development strategy of DGG departments, which focus on geometric-graphic component of the concept of engineering structuring, including interdisciplinary approach combined with modern trends in the development of modern CAD technology based on the ideology of Industrial 4.0 (Voronina & Moroz, 2017).

This study examines the possibility of DGECGCG FLM. It is a relatively new teaching technology that is successfully developing nowadays. Flipped (inverted) classroom is a teaching strategy and a type of blended learning that changes the traditional learning environment, often providing the training content online, outside the class. It moves the activity, which is traditionally considered as homework, in class. In a flipped classroom, students watch online lectures, collaborate in online discussions, or carry out research at home and engage in concepts in the classroom with the guidance of a mentor (Flipped classroom, 2017). FLM is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (Definition of Flipped Learning, 2014).

The goals and objectives of the study

The purpose of this article was to examine and describe the current state of theory and practice in the field of DGECGCG educational process that uses flipped concept of learning as a major pedagogical strategy.

The main tasks were the following three:

- to discuss the effectiveness of DGECGCG FLM, its advantages and disadvantages compared to traditional teaching method;
- to give practitioners recommendations with the help of critical evaluation and synthesis of existing researches;
- to investigate students' attitude to this teaching model in general, to the role of professor's personality and to the role of teaching materials in particular.

LITERATURE REVIEW

Foreign research analysis

Jonathan Bergman and Aaron Sams are pioneers of flipped classroom and founders of FLM. They are two teachers, who in 2007 came up with an idea on how to provide athletes missing classes with their lectures. Then they developed this idea into a new educational direction (Bergmann & Sams, 2012). Clintondale High School (Detroit, USA) is the first "inverted" school, which completely switched to the principle of "inverted" learning in 2010 (Inverted class: the technology of teaching the XXI century, 2017).

Definitions, positive and negative points, recommendations for teachers and professors, justification of the need to modernize the existing inverted courses on the grounds of reasonable pedagogy have been given and considered in a sufficient number of studies (Hamdan et al., 2013; Van Veen, 2013; Davies, Dean & Ball, 2013; Furse, Ziegenfuss & Bamberg, 2014; Bogam, 2015; Abeysekera & Dawson, 2015; Sahin & Kurban, 2016; Yarbro et al., 2017). The studies were built on the energy of thousands of educators inspired by the influential book Flip Your Classroom by J. Bergmann & A. Sams (2014). This installment is all about what happens next - when a classroom is truly student-centered and teachers are free to engage with students on an individual level. The book, compiled by Jason Bretzmann is a great resource to help you answer some of the questions you might have once you've decided to flip (Bretzmann, 2013).

A survey conducted by the Center for Digital Education and Sonic Foundry found that 29% of faculties are currently using FLM, with another 27% saying they plan to use it within the next 12 months (Bart, 2013). A brief outline of the results achieved from a Staff member Survey on Flipped Teaching Provision of Coventry University about their use of FLM showed, that 89% of respondents from Engineering used FLM (Coventry University Staff Survey on Flipped Teaching Provision, 2016). Some researches affirm that flipping of a large lecture hall is quite possible and effective and it is an exciting place for both instructors and students (Jungic et al., 2015; McKittrick & Ligon, 2015; Bailey & Smith, 2013).

Nevertheless, the flipped model is still underutilized and underexplored in the higher education context (Chen et al., 2014). The use of the flipped classroom has received less attention in engineering subjects and currently only limited number of researches exist (Kerr, 2015).

In the works of J. Yarbro (2017); A. Karabulut-Ilgu, N. J. Cherrez & Ch. T. Jahren (2017); N. V. Mendoza Diaz (2015); C. Papadopoulos & A. Santiago Roman (2010); E. Choi (2014); J. W. Everett et al. (2014); D. Rodrigues & A. Mouraz (2014); M.Borrego, M. J. Foster & J. E. Froyd (2014); S. B. Velegol, S. E. Zappe & E.Mahoney (2015); I. R. Chohan (2016) multiple case studies, systematic reviews of studies of the method of FLM in engineering education were carried out.

Most of the researches in the field of engineering education based on FLM have been conducted on the basis of short-term studies and on feedback from professors and students (Bland, 2006; Kim et al., 2014; Kwan Lo &, Foon Hen, 2017).

Russian research analysis

New technologies make inverted teaching possible and, nowadays, it is irradiating in secondary and higher schools (Miroshnikova, 2016, Artyukhina et al., 2016). In the work of S. G. Litvinova (2015) a definition of "Flipped learning" is given as the technology for implementing a learning process in which students are expected to listen and watch video lessons with the help of gadgets, and also learn additional sources on the basis of electronic tools themselves (during off-hour time), and then in the classroom together with the teacher discussing new concepts and various ideas, which makes it possible to "consolidate" the material studied and learn how to apply the knowledge gained in practice. "Inverted learning inverts traditional methods of teaching, realizing the supply of material outside the classroom and translating homework into a lesson" (Kharitonova, 2014). Such lessons can become a means for the teacher to create their own mixed lessons using a variety of techniques and methods of mixed instruction. Video content can be filled with completely different educational material, depending on the program requirements for the subject. An example of such content can be video lectures, video seminars, video materials of online discussions, documentary video reports, as well as various videos using animated files or images (Miroshnikova, 2016). Teaching activities may be different, but in order to intensify the learning process and optimize it, new methods and techniques can be introduced, using improvised linguistic and speech materials, experimental results, analysis of new and already-known material, debates or presentations, discussions about current events, peer review, project-based learning (Litvinova, 2015).

The paper by A. I. Artyukhina et al. (2016) discloses the problem of using FLM on the example of training students in the "Architect of landscape design". The work says that at present there is a modernization of higher education, which entails many changes in the established provisions of the education process. These innovations concern all participants of educational activity (both students and teachers). The time for general classroom sessions has decreased, resulting in a reduction in the number of theoretical training classes (introductory lectures, lecture courses), practical classroom activities (term papers, course projects for architects) and training practices. At the same time, the hours of classroom instruction were translated into the independent work of students, which leads to a revision of the technology of conducting classes, plans and tasks for independent work of students, as well as forms of verification of the work performed.

The works of T. T. Rybalko (2016) state that the concept of the "inverted" class and its introduction into university practice as one of the types of interactive teaching allow us to speak of it as yet another innovative, quite successful model of differentiated education in conditions of higher education.

In the works of V. E. Zhukovskiy (2017), based on the experience of teaching network technologies using FLM, the prerequisites and necessity of 17 transitions to this model, its main key moments, and advantages have been shown, as well as the problems that arise and the ways to solve them.

MATERIALS AND METHODS

Theoretical and empirical methods

To test the hypothesis of the study, a set of various methods complementary to each other was used:

- **theoretical**: analysis of the works of teachers and psychologists on the problem of research; analysis of methodological and educational literature; theoretical justification of the possibility of introducing FLM of DGECGCG in engineering universities;
- **empirical**: observation, ascertaining, pedagogical experiment, questioning, testing, cluster analysis of the results of experimental work.

Base of research

The study was conducted on the basis of Descriptive Geometry and Graphics department of the Saint Petersburg Mining University. 25 first year students of electro-mechanical faculty and 4 professors of the department participated in the experiment.

Stages of research

The study was conducted in three stages:

- **at the first stage**, a theoretical analysis of existing methodological approaches in the scientific literature, dissertational works on problems, as well as theory and methodology of pedagogical research was carried out. The purpose, the methods of the research were singled out and a plan for experimental research was drawn up;
- **at the second stage**, experimental work was carried out, the conclusions of the experimental work were analyzed, tested and clarified;
- **at the third stage**, the experimental work was completed, theoretical and practical conclusions were refined, the results obtained were summarized and systematized.

Progress and description of the experiment

In this case, issues related to the segmentation of the field of education have been examined; namely, the study of the effectiveness of the application of FLM.

To carry out the research, a survey of 10 questions was developed:

1. Do you think that DGECGCG will be sufficiently useful and necessary for further education?
2. Do you think that this subject will be sufficiently useful and necessary for professional activity?
3. What do you know about the theory and methods of FLM?
4. Do you want to try this technique when studying subjects?

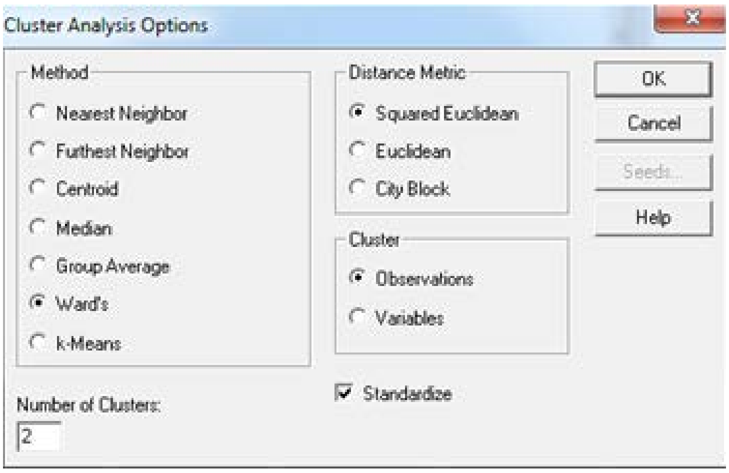

Figure 1. Cluster Analysis Options

5. Do you think that this technique will make it possible to study the subject more deeply?
6. Do you think that this technique will make studying of this subject easier?
7. Do you think that with such a technique the role of teaching materials and self-study increases?
8. What is the role of the professor's personality in this method?
9. What is your attitude to learning in general?
10. Do you find it easy to study?

More than 25 respondents were interviewed. The STATGRAPH program was used as a tool for segmentation. As a result of application of the program data, the initial set of objects was divided into classes or subgroups of similar objects. The calculation process is divided into several stages. Firstly, measures and similarities of objects were determined (the Euclidean metric, the square of the Euclidean metric, the metrics of Cherbyshev, etc.). After that, the question of the rules for combining clusters that can be realized by the following methods (two way joining K-clastering). In programs, you can choose a rule of a hierarchical clustering (single-link method, full-link method, Ward's method, etc.) (**Figure 1**). All these algorithms differ in the rules for combining objects into clusters.

In this case, when the set was divided into clusters, the following methods were applied: the square of the Euclidean metric, the Ward's method.

Further, the segmentation of interviewee into two clusters was carried out, which revealed the following patterns.

RESULTS

The results of the study of the attitude of the students of the experimental group to FLM

All the interviewee were divided into two segments with 80% of respondents in the first segment and 20% in the second.

When describing the various clusters, we will focus only on those questions that characterize a sufficient difference.

As can be seen from **Table 1** (**Figure 2**) the first two questions:

Table 1. The results of cluster analysis of students' attitude to FLM

Cluster	Col_1	Col_2	Col_3	Col_4	Col_5	Col_6	Col_7	Col_8	Col_9	Col_10
1	9.25	9.8	5.95	9.35	9.2	6.65	9.1	8.6	8.2	6.3
2	7.0	6.8	4.8	9.6	9.0	8.0	9.8	9.4	6.0	4.8

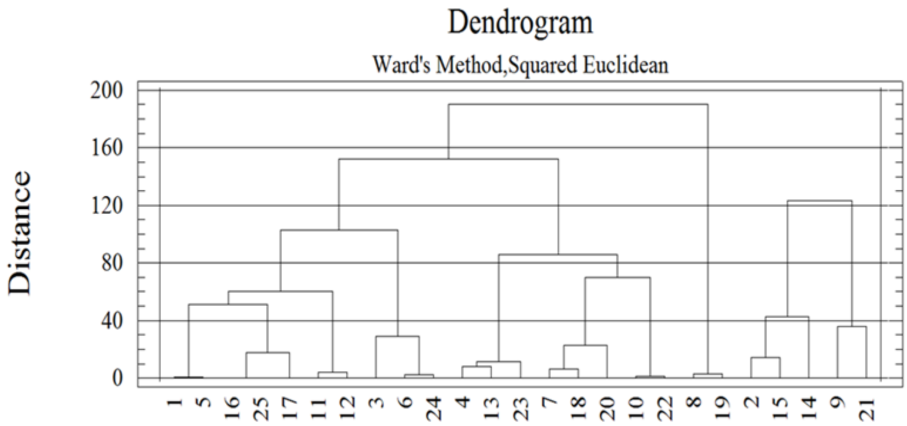

Figure 2. Dendogram obtained using Ward's method for the analysis of two clusters of students studying on the basis of FLM

1. Do you think that DGECGCG will be sufficiently useful and necessary for further education?
2. Do you think that this subject will be sufficiently useful and necessary for professional work?

immediately divide students into two different groups:

1. In the first cluster, students believe that the subject will be useful for both further training and professional activities. Although even after the training conducted on the presented methodology, students do not fully understand this method (see question 3- the assessment is very average).
2. Students in the second cluster are sure that this method will facilitate the training on this subject (6th question), they found it harder to study (question 9-10).

For all that students from two segments are fairly loyal to this technique, and not against using it for studying other subjects (question 4 is greater than 9).

We want to focus on two points that carry information related to the use of teaching materials in the educational process, and also what the role of the professor's personality is in the teaching process.

First, we will review and analyze the students' answers to the question "What is the role of the professor's personality in this method?" Here we can see from the data obtained (the average score of the answer is 8.6 in the first segment, 9.4 in the second segment), that the students' attitude to this issue is almost the same. At the same time, students entering both the first and the second segment believe that the role of the professor's personality when using this technique is very weighty.

Let's consider the results concerning another question "Do you think that with such a technique the role of teaching materials and self-study increases?" According to the results obtained (the average score of the answer is 9.1 in the first segment, 9.8 in the second segment), the students of the two segments also consider it important to use teaching materials for individual work.

Table 2. The results of systematic review

No	Course	Author, Year
1	Mathematics, Linear Algebra	Kay & Kletskin, 2012; Ingram et al., 2014; Love et al., 2014; Talbert, 2014; Zengin, 2017
2	Upper-division Engineering	Mason, Shuman & Cook, 2013
3	Fluid Mechanics	Mcclelland, 2013
4	Information Systems	Mok, 2014
5	Computer Programming	Puarungroj, 2016
6	Computer Engineering	Redekopp & Ragusa, 2013
7	Mathematics Software	Zengin, 2017
8	Software Engineering	Gannod, Burge & Helmick, 2008; Choi, 2013
9	Introductory Programming (CS1) to Engineering, Engineering Technology, and Software Engineering for undergraduates	Campbell, 2014; Amresh, 2013
10	Mechanics of Materials	Lee, Zhu & Middleton, 2016; Thomas & Philpot, 2012
11	Electrical Engineering	Bland, 2006; Kaleem, Jacobson & Khan, 2016
12	Geological Engineering	Hagen & Fratta, 2014
13	Biomedical Engineering	Ankeny & Krause, 2014
14	Materials Science. Solar Cells, Fuel Cells and Batteries: Materials for the Energy Solution	Clemens et al., 2013
15	Mid-level Undergraduate Engineering Course	Bishop & Verlegere, 2013
16	Undergraduate Circuits Analysis	Rockland, 2013
17	Undergraduate Statistics	Wilson, 2013
18	Undergraduate Course for Information Systems	Mok, 2014
19	Flexible work-based learning to Engineering postgraduate students	Simpson et al., 2003
20	STEM	Talbert & Valley, 2012
21	Large Systems Design Class	Bailey & Smith, 2013

Findings emerged as a result of systematic review

The goal was to understand the current state of affairs and practice of using DGECGCG FLM in order to form our own opinion. As a result, this method in our understanding has developed as a unique combination of teaching theories previously considered incompatible:

- active, problem-based training activities built on constructivist ideology, the key idea of which lies in the fact that knowledge cannot be transferred to the learner in the final form, but it is only possible to create pedagogical conditions for successful self-independent construction and growth of students' knowledge.

- pre-recorded educational lectures and developed electronic teaching aids based on behavioral principles. Materials are provided to students more as homework, and as a result, the classroom time remains free for training activities that cannot be automated or computerized.

Some kindred studies on FLM are set out in **Table 2**.

Many scientists believe flipping pedagogy has the potential to work well across a range of mathematics, as well as other STEM courses, and are encouraged by the growing national interest in this type of pedagogy, which will certainly lead to new insights, strategies, and tools (McGivney-Burelle, 2013).

However, we have not found any researches in the field of DGECGCG FLM.

The review of 87 articles on the subject, as well as the results of the conducted experiment, showed the following:

1. FLM deliberately shifts instruction to a learner-centered model in which during classroom work students explore certain topics more deeply. In a flipped classroom, content delivery may take a variety of forms. Often video lessons prepared by the teacher or third parties are used for content delivery, although online collaborative discussions, digital research, text readings may be used as well.
2. FLM allows to solve the basic educational and organizational objectives: to organize the learning process driven by the impact of a teacher; to ensure the active participation in the academic work of students with different levels of training and the amount of previous knowledge at the time of the lessons (prepared and not prepared; the strong and the weak); to establish systematic control over the process of learning.
3. FLM is widespread in engineering education. Despite this, there is no consensus on the issue of its effectiveness in engineering education.
4. The number of studies on the theoretical framework that determine the development and evaluation of the FLM approach is not sufficient. Evaluation methods are mainly limited to quantitative data obtained from course evaluations and surveys. There is also a lack of qualitative research for a deeper understanding of phenomena in specific contexts.
5. Most of the researches in the field of FLM of engineering courses focus on documenting the process of designing and developing teaching methods and curriculum programs, conclusions are based on short-term studies, feedback from teachers and students.
6. FLM gives advantages to professors, but can also create problems for them.

The study identifies certain features of DGECGCG FLM; namely:

1. The role of the professor's personality. A professor bears the role of a mentor, whose activities are aimed at coordinating the training of students; that is, providing assistance, counseling and creation of an educational and problem situation for cognitive and research activities. FLM promotes the development of an individual approach in teaching. With the use of FLM, the role of professors is becoming more significant.
2. The emphasis should be shifted to the process of students' cognitive activity, during which they discover new knowledge.
3. Overwhelming majority of teaching materials should be presented in the form of electronic educational resources: YouTube, KhanAcademy, LearnZillion, EdPuzzle, eduCanon, VideoNotes, aboTeachem etc. EdPuzzle (https://edpuzzle.com/) is a service that allows you to assemble the video, add voice comments and questions about the subject of educational material. Professors can take advantage of existing video training database, which will greatly speed up the search for the necessary material. The service makes it possible to track which of the students have already reviewed the video and how they coped with the tasks proposed. VideoNotes (http://www.videonot.es/) is a service that can be used for a variety of tasks. When watching a video using this service, a panel for notes appears on the right which is automatically synchronized with the timeline of the video. This is very convenient if a professor wants to split the video into parts or to receive feedback from the students. Also, all notes can be stored on GoogleDrive (Rybalko, 2016).
4. Classroom training should be based on solving problems, discussions.
5. FLM provides professors with free time for communication with students in the class. Engaging with students on an individual level becomes possible. More attention can be given to those students who have difficulty comprehending a subject or doing their homework, and gifted students will have more freedom to learn independently at their own pace.

DISCUSSION

Flipped Network (FLN) website includes links to videos that teachers can use to flip, announcements for events related to FLM, how-to videos for less experienced flippers, archived webinars, and descriptions of books related to the flipped approach. In addition, the Flipped Network houses the Flipped Learning Community (FLC), which connects 25,000 educators from around the world who share resources and best practices; teachers can join the FLC at no cost by creating an account (Kostka & Lockwood, 2015).

Most researchers note the undoubted merits of inverted learning (Rutherfoord & Rutherfoord, 2013; Herreid & Schiller, 2013; Hamdan et al., 2013; Chao, Chen & Chuang, 2015). It gives students statistically significant advantages in difficult, applied areas emphasized in class. Furthermore, students in the flipped classroom feel they learned more and enjoyed the course more than those in a traditional classroom (Touchton, 2015). A learning experience that can persist after the course ends. In the inverted classroom, students shift from being passive recipients of information to active evaluators and users of information, and the instructor shifts from an impersonal lecturer to an involved coach. The classroom environment shifts from a transactional model to a relational (Talbert & Valley, 2012). Students found this approach to be more motivating in that it allowed for greater differentiation of instruction (Davies, Dean, & Ball, 2013). Students reported that they were satisfied with the course, their attendance improved, and their study efforts increased (Chen et al., 2014). Students in an in-flipped classroom exhibit better individualization than those in a traditional classroom and have increased interest in cooperative learning. Students are more easily engaged in lectures and develop self-directed, self-regulating, and self-determined skills through the proposed method (Chiang & Wang, 2015).

In the case of inverted learning, the role assigned to the professor also changes in turn. Instead of becoming a "sage on stage", the instructor now becomes a "guide", presenting the professor's role to that of a cognitive coach (Berrett, 2012), students faculty contact could be reduced by two-thirds (Baepler, Walker & Driessen, 2014). The traditional paradigm treats a student as an empty container, into which knowledge is poured, and the inverted paradigm treats the pupil as an active learner who reconstructs knowledge from information (Van Veen, 2013; Ivala, Thiart & Gachago, 2013; Berrett, 2012; Gannod, Burge & Helmick, 2008).

But researchers also note the difficulties. Converting a course from a traditional teaching method to an inverted format requires a serious investment of time from the professors, the time that it takes to make the videos; time to re-conceptualize class time; and time for students to become accustomed to a new model of teaching and learning. And it also requires the commitment, and support, of administrators who allow teachers to try new and innovative teaching strategies (Drake, Kayser & Jacobowitz, 2016). The instructor may have to spend much time preparing a lot of teaching materials and class activity assignments (Puarungroj, 2016). An additional point is that this technique entails high start-up costs (Rockland et al., 2013). Time is needed to change students' attitude regarding their own role into more active participation. Also lecturers' training needs to be more focused. (Rodrigues & Mouraz, 2014). Some students believed that the flipped classroom helped them learn more, however, students' performance on the exams was not improved over other students (Canino, 2015).

Some authors do not believe there will be any suitable replacement for old fashioned problem solving nor do they believe that videos will make the teacher any less relevant or important in the development of the student (Chetcuti, Thomas & Pafford, 2014).

The success of a flipped approach hinges on the synergy between instructor and students and requires sustained motivation and contribution before, during, and after live instruction. When used appropriately, flipping the classroom is a valuable addition to higher education practice (Estes, Ingram & Liu, 2014).

CONCLUSION

This systematic review of FLM researches helps design and evaluate FLM courses in an engineering university. The study is timely as FLM has already gained popularity among professors in engineering, but has not covered all areas of engineering learning yet.

It can be concluded that both for students with strong and poor learning motivation, it is possible to fully apply the presented methodology. In DGECGCG FLM, two clusters of students were singled out:

- the first cluster believes that the subject will be useful to them in the future, they find it easy to study and they like to learn. The technique itself also makes positive impressions on them.
- learning is more difficult for the second cluster of students and does not bring them. Although, in this case, the presented methodology is perceived by the students rather positively.

Students of both segments do not know the principles of methodology very well, and at the beginning of the session, it is necessary to pay special attention to this issue.

It should be noted that for the creations of pedagogy of FLM DGECGCG, the following are absent:

- scientifically based researches that study various aspects of tried and tested implementation of education;
- tried and tested programs and training materials of the model of inverted training, created on the basis of reasonable theoretical bases and methods of evaluation;
- recommendations for researchers, practitioners and policy makers for the development of action plans.

REFERENCES

Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research. *Higher Education Research and Development*, *34*(1), 1-14.

Amresh, A., Carberry, A. R., & Femiani, J. (2013). Evaluating the effectiveness of flipped classrooms for teaching CS1. *Proceedings of Frontiers in Education Conference, FIE.* Oklahama City, OK: IEEE Xplore Digital Library, 733-735.

Ankeny, C. J., & Krause, S. J. (2014). Flipped biomedical engineering classroom using pencasts and muddiest point web-enabled tools. *Proceedings of 121st ASEE Annual Conference & Exposition*, Indianapolis, IN, 1-17.

Artyukhina, A. I., Velikanova, O. F., Tretjak, S. V., Chumakov, V. I., Velikanov, V. V., & Ivanova, N. V. (2016). Interactive teaching methods in the development of the situational readiness of a specialist. *The Austrian Journal of Humanities and Social Sciences*. 1-2 (January-February), 48-50.

Baepler, P., Walker, J. D., & Driessen, M. (2014). It's not about seat time: Blending, flipping, and efficiency in active learning classrooms. *Computers and Education*, *78*, 227–236.

Bailey, R., & Smith, M. C. (2013). Implementation and Assessment of a Blended Learning Environment as an Approach to Better Engage Students in a Large Systems Design Class. *ASEE Annual Conference & Exposition*, Atlanta, Georgia, p.13.

Bart, M. (2013, November 20). Survey confirms the growth of the flipped classroom. Faculty Focus. Retrieved June 7, 2017, from https://www.facultyfocus.com/articles/blended-flipped-learning/survey-confirms-growth-of-the-flipped-classroom/

Bergmann, J., & Sams, A. (2012). Flip Your Classroom: Reach Every Student in Every Class Every Day. *International Society for Technology in Education*, p.112.

Bergmann, J., & Sams, A. (2014). Flipped Learning: Gateway to Student Engagement. p.182.

Berrett, D. (2012). How flipping the classroom can improve the traditional lecture. Retrieved June 7, 2017 from http://ribonode.ucsc.edu/SciEd/pdfs/CHI_GuideFlippedClassroom.pdf

Bishop, J., & Verleger, M. (2013a). Testing the flipped classroom with model-eliciting activities & video lectures in a mid-level undergraduate engineering course. *Proceeding of Frontiers in Education Conference, FIE*.

Bishop, J., & Verlegher, M. (2013b). The Flipped Classroom: A Survey of the Research. *ASEE Annual Conference & Expositio*n, Atlanta, Georgia, p.13.

Bland, L. (2006). Applying flip/inverted classroom model in electrical engineering to establish life-long learning. *Proceedings of ASEE Annual Conference & Exposition*, Chicago, Illinois.

Bogam, R. R. (2015). Effect of Flipped Classroom Model on Knowledge of Medical Students in Context of Community Medicine. *International Journal of Advanced Research in Education & Technology (IJARET), 2*(3), 111-113.

Borrego, M., Foster, M. J., & Froyd, J. E. (2014). Systematic literature reviews in engineering education and other developing interdisciplinary fields. *Journal of Engineering Education*, *103*(1), 45-76.

Boudet, F. J., & Talón, J. (2012). Use of wiki as a postgraduate education learning tool: A case study. *International Journal of Engineering Education, 28*(6), 1334-1340.

Bretzmann, J. (2013). Flipping 2.0: Practical Strategies for Flipping Your Class, p. 328.

Cai, J., Youngblood, V. T., Khodyreva, E. A., & Khuziakhmetov, A. N. (2017). Higher Education Curricula Designing on the Basis of the Regional Labour Market Demands. *Eurasia Journal of Mathematics, Science & Technology Education, 13*(7), 2805–2819.

Campbell, J. (2014). Evaluating an inverted CS1. *SIGCSE 2014 - Proceedings of the 45th ACM Technical Symposium on Computer Science Education*.

Canino, J. V. (2015). Comparing student performance in thermodynamics using the flipped classroom and think-pair-share pedagogies. *ASEE Annual Conference & Exposition*, Seattle, WA.

Chao, C.-Y., Chen, Y.-T., & Chuang, K.-Y. (2015). Exploring students' learning attitude and achievement in flipped learning supported computer aided design curriculum: A study in high school engineering education. *Computer Applications in Engineering Education, 23*(4), 514–526.

Chen, Y., Wang, Y., Kinshuk, & Chen, N. S. (2014). Is FLIP enough? Or should we use the FLIPPED model instead? *Computers and Education*, *79*, 16-27.

Chetcuti, S., Thomas, H., & Pafford, B. (2014). Flipping the engineering classroom: lessons learned in the creation, production and implementation. Retrieved June, 7, 2017 from https://www.asee.org/documents/sections/middle-atlantic/fall-2013/7-Hans-Flipping-the-Engineering-Classroom.pdf

Chiang, Y., & Wang, C. (2015). Effects of the in-flipped classroom on the learning environment of database engineering. *International Journal of Engineering Education*, *31*(2), 454-460.

Chohan, I. R. (2016). Group Dynamics in Flipped and Social Learning Situations in Higher Education. Retrieved June, 6, 2017 from http://conference.pixel-online.net/FOE/files/foe/ed0006/FP/2975-ITL1895-FP-FOE6.pdf

Choi, E. (2013). Applying inverted classroom to software engineering education. *International Journal of EEducation, E-Business, E-Management and E-Learning*, *3*(2), 121-125.

Clemens, B. M., Nivargi, C., Jan, A., Lu, Y., Schneider, E., & Manning, J. (2013). Adventures with a flipped classroom and a materials science and engineering MOOC: «fools go where angels fear to tread». *Proceedings of Materials Research Society Symposium*. 1583. Boston, MA.

Coventry University Staff Survey on Flipped Teaching Provision (2016). Retrieved June, 6, 2017 from http://dmll.org.uk/wp-content/uploads/2016/08/flipped-phase-1-staff-survey.pdf

Davies, R. S., Dean, D. L., & Ball, N. (2013). Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Educational Technology Research and Development*, *61*(4), 563–580.

Definition of Flipped Learning. (2014, March 12). Retrieved June 19, 2017 from http://fln.schoolwires.net/domain/46

Drake, L., Kayser, M., & Jacobowitz, R. (2016). The Flipped Classroom. An Approach to Teaching and Learning. *A 2020 VISION for public education in Ulster County*. The Benjamin Center, SUNY New Paltz Ulster County School Boards Association, State University of New York, New Paltz, NY. Retrieved June, 6, 2017 from http://www.newpaltz.edu/media/the-benjamin-center/P.Brief_2020Vision-Flipped%20classroom.pdf

Estes, M., Ingram, R., & Liu, J. C. (2014). A review of flipped classroom research, practice, and technologies. *International HETL Review*, 4, Retrieved June, 7, 2017 from https://www.hetl.org/a-review-of-flipped-classroom-research-practice-and-technologies/

Everett, J. W., Morgan, J. K., Stanzione, J. F., & Mallouk, K. E. (2014). A hybrid flipped first-year engineering course. *Proceedings of 121st ASEE Annual Conference & Exposition*, Indianapolis.

Flipped classroom. (2017, June 6). In Wikipedia, the free encyclopedia. Retrieved June 19, 2017 from https://en.wikipedia.org/wiki/Flipped_classroom

Furse, C. M., Ziegenfuss, D., & Bamberg, S. (2014). Learning to teach in the flipped classroom. *IEEE Antennas and Propagation Society, AP-S International Symposium (Digest)*, 910-911.

Gannod, G. C., Burge, J. E., & Helmick, M. T. (2008). Using the inverted classroom to teach software engineering. *Proceedings of the 30th international conference on Software engineering*. Leipzig, Germany, 777-786.

Gorev, P. M., & Kalimullin, A. M. (2017). Structure and Maintenance of a Mathematical Creative Lesson as a Mean of Pupils' Meta-Subject Results Achievement. *Eurasia Journal of Mathematics, Science & Technology Education, 13*(6), 2701–2720.

Hagen, E. J., & Fratta, D. (2014). Hybrid learning in geological engineering: Why, how, and to what end? *Proceedings of Geo-Congress 2014 Technical Papers: Geocharacterization and modeling for sustainability* (pp. 3920–3929). Atlanta, GA: ASCE.

Hamdan, N., McKnight, P., McKnight, K., & Arfstrom, K. M. (2013). A review of flipped learning. Retrieved June 6, 2017, from https://www.pearson.com/content/dam/one-dot-com/one-dot-com/global/Files/efficacy-and-research/he/fl-1-LitReview_2014_FlippedLearning_vFinal_JK_WEB.pdf

Herreid, C. F., & Schiller, N. A. (2013). Case Studies and the Flipped Classroom. *Journal of College Science Teaching*, *42*(5).

Ingram, D., Wiley, B., Miller, C., & Wyberg, T. (2014). A Study of the Flipped Math Classroom in the Elementary Grades. *Center for Applied Research and Educational Improvement*, Saint Paul, MN: University of Minnesota, College of Education and Human Development.

Inverted class: the technology of teaching the XXI century. (2017, June 6). Retrieved June 19, 2017 from http://www.ispring.ru/elearning-insights/perevernutyi-klass-tekhnologiya-obucheniya-21-veka/

Ivala, E., Thiart, A., & Gachago, D. (2013). A lecturer's perception of the adoption of the inverted classroom or flipped method of curriculum delivery in a hydrology course, in a resource poor university of technology. *Proceedings of the 8th International Conference on E-Learning* (pp. 207–214). Cape Town, South Africa: ACPI.

Jungic, V., Kaur, H., Mulholland, J., & Xin, C. (2015). On flipping the classroom in large first year calculus courses. *International Journal of Mathematical Education in Science and Technology, 46*, 1–8.

Kaleem, F., Jacobson, D. W., & Khan, F. (2016). Comparison of Traditional, Flipped, and Hybrid Teaching Methods in an Electrical Engineering Circuit Analysis Course. *ASEE Annual Conference & Exposition*, New Orleans, LA, p.15.

Karabulut-Ilgu, A., Cherrez, N. J., & Jahren, Ch. T. (2017, February 20). A systematic review of research on the flipped learning method in engineering education. *British Journal of Educational Technology*. Retrieved June 16, 2017, from http://onlinelibrary.wiley.com/doi/10.1111/bjet.12548/pdf

Kay, R., & Kletskin, I. (2012) Evaluating the use of problem-based video podcasts to teach mathematics in higher education. *Computers & Education, 59*, 619–627.

Kerr, B. (2015, September 20-24). The flipped classroom in engineering education: A survey of the research. *Proceedings of 2015 International Conference on Interactive Collaborative Learning (ICL*), Florence, Italy. Retrieved June 19, 2017, from http://www.weef2015.eu/Proceedings_WEEF2015/proceedings/papers/Contribution1252.pdf

Kharitonova, M. V. (2014). How to turn the lesson? Modern methods and methods of teaching. *Proceedings of the All-Russian Festival of Advanced Pedagogical Experience*, 1. Retrieved June 6, 2017, from http://nauka-it.ru/

Kim, M. K., Kim, S. M., Khera, O., & Getman, J. (2014). The experience of three flipped classrooms in an urban university: An exploration of design principles. *Internet and Higher Education*, *22*, 37–50.

Kostka, I., & Lockwood, R. B. (2015, August). What's on the Internet for Flipping English Language Instruction? *The Electronic Journal for English as a Second Language*, *19*(2). Retrieved June 6, 2017, from http://www.tesl-ej.org/pdf/ej74/int.pdf

Kumar, S., & Hsiao, K. (2007). Engineers learn "soft skills the hard way": Planting a seed of leadership in engineering classes. *Leadership Management in Engineering*, *7*, 18–23.

Kwan Lo, Ch., & Foon Hen, Kh. (2017). A critical review of flipped classroom challenges in K-12 education: Possible solutions and recommendations for future research. *Research and Practice in Technology Enhanced Learning, 12*(4), 1-22.

Lee, A., Zhu, H., & Middleton, J. A. (2016). Effectiveness of flipped classroom for mechanics of materials. *ASEE Annual Conference and Exposition*.

Levina, E. Y., Voronina, M. V., Rybolovleva, A. A., Sharafutdinova, M. M., Zhandarova, L. F., & Avilova, V. V. (2016). The Concepts of Informational Approach to the Management of Higher Education's Development. *International Journal of Environmental & Science Education*, *11*(4), 9913-9922.

Litvinova, S. G. (2015). Technology "Inverted Learning" in the cloud-oriented learning environment as a component of the development of media education in the secondary school. *Mediasphere and media education: the specifics of interaction in the modern sociocultural space*, *47*(3), 49-66.

Love, B., Hodge, A., Grandgenett, N., & Swift, A. W. (2014). Student learning and perceptions in a flipped linear algebra course. *International Journal of Mathematical Education in Science and Technology*, *45*, 317–324.

Mason, G. S., Shuman, T. R., & Cook, K. E. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. *IEEE Transactions on Education*, *56*(4), 430-435.

Mcclelland, C. J. (2013). Flipping a large-enrollment fluid mechanics course -Is it effective? *ASEE Annual Conference and Exposition*, Atlanta, GA.

McGivney-Burelle, J., & Xue, F. (2013). Flipping Calculus. *Primus, 23*(5), 477–486.

McKittrick, C., & Ligon, E. (2015). Flipping a Large Lecture Hall Class: Creating Scaffolded Interactive Learning Using Technology and CaseBased Group Activities in a 390-Seat Auditorium. *Conference on Teaching Large Classes*. The Inn at Virginia Tech and Skelton Conference Center Virginia Tech, Blacksburg, Virginia, 17-18.

Mendoza Diaz, N. V. (2015, August 3-4). The Inverted Engineering Classroom: An Analysis of the Impact in a First Year Engineering Program. *Proceedings of the 7th First Year Engineering Experience (FYEE) Conference*, Roanoke, VA, M4C1…M4C3.

Miroshnikova, N. N. (2016, March 27). "Inverted class" - an innovative model in teaching foreign languages in higher education. *Proceedings of the Vth International scientific-practical conference «Innovative technologies in science and education: materials»*, Cheboksary, Russia: Interactive Plus, *1*(5), 214-216.

Mok, H. N. (2014). Teaching tip: The flipped classroom. *Journal of Information Systems Education*, *25*, 7–11.

Papadopoulos, C., & Santiago Roman, A. (2010). Implementing an inverted classroom model in engineering statics: Initial results. *Proceedings of the 117th ASEE Annual Conference & Exposition*, Louisville, Kentucky.

Puarungroj, W. (2016). Inverting a Computer Programming Class with the Flipped Classroom. *The Twelfth International Conference on eLearning for Knowledge-Based Society*, 11-12 December 2015, Thailand, 40.1-40.7.

Redekopp, M. W., & Ragusa, G. (2013). Evaluating flipped classroom strategies and tools for computer engineering. *ASEE Annual Conference & Exposition*, Atlanta, GA.

Rockland, R. (2013). Learning outside the classroom - Flipping an undergraduate circuits analysis course. *Proceedings of the ASEE Annual Conference and Exposition*.

Rodrigues, D., & Mouraz, A. (2014). "Flipped classroom" as new challenge in higher education: a multi case study. *Challenges in Higher Education*, 207-220.

Rutherfoord, R., & Rutherfoord, J. (2013). Flipping the classroom - Is it for you? *Proceedings of the 2013 ACM SIGITE Annual Conference on Information Technology Education*.

Rybalko, T. T. (2016). Innovative model "Inverted class" in learning a foreign language in high school. *Proceedings of the 10th Professional Linguistic Education International Scientific and Practical Conference*. Nizhny Novgorod, Russia: RANEPA, 278-284.

Sahin, M. & Kurban, K. H. (2016). The Flipped Approach to Higher Education: Designing Universities for Today's Knowledge Economies and Societies, p.229. Retrieved June 6, 2017, from https://www.amazon.com/Flipped-Approach-Higher-Education-Universities/dp/1786357445

Simpson, W., Evans, D., Eley, R., & Stiles, M. (2003). Findings from the HEI "Flip" project: Application issues. *International Journal of Continuing Engineering Education and Lifelong Learning*, *13*(5), 471-482.

Talbert, R. (2014). Inverting the Linear Algebra classroom. PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies, *24*, 361–374.

Talbert, R., & Valley, G. (2012). Learning MATLAB in the inverted classroom. *ASEE Annual Conference & Exposition*, San Antonio, TX.

Thomas, J. S., & Philpot, T. A. (2012). An inverted teaching model for a mechanics of materials course. *ASEE Annual Conference & Exposition*, San Antonio, TX.

Touchton, M. (2015). Flipping the Classroom and Student Performance in Advanced Statistics: Evidence from a Quasi-Experiment. *Journal of Political Science Education*, *11*(1), 28-44.

Van Veen, B. (2013). Flipping signal-processing instruction (SP education). *IEEE Signal Processing Journal*, *30*(6), 145-150.

Velegol, S. B., Zappe, S. E., & Mahoney, E. (2015). The Evolution of a flipped classroom: Evidence-based recommendations. *Advances in Engineering Education*, *4*(3), 1-37.

Voronina, M. V., & Folomkin, A. I. (2017). Educational library for the automation of design calculations springs using SOLIDWORKS API. *Man in India*, *97*(3), 443-451.

Voronina, M. V., & Moroz, O. N. (2017). A substantiation of foresight research of development strategy of descriptive geometry, engineering geometry and computer graphics departments on the basis of industrial 4.0 ideology. *Man in India*, *97*(3), 375-389.

Voronina, M. V., & Muratbakeev, E. Kh. (2017). History and modern interpretations of descriptive geometry in today's Russian engineering university. *Man in India*, *97*(8).

Voronina, M. V., & Simenko, E. V. (2017). Constructive Methods of Forming Surfaces. *International Journal of Applied Engineering Research*, *12*(6), 956-962.

Voronina, M. V., & Tretyakova, Z. O. (2017). The Experience of Teaching of Descriptive Geometry and Engineering Graphics in Russian language as a Foreign Language. *International Journal of Environmental & Science Education*, *12*(1), 25-34.

Voronina, M. V., Moroz, O. N., Tretyakova, Z. O., & Folomkin, A. I. (2016). Descriptive geometry in educational process of Technical University in Russia today. *International Journal of Environmental & Science Education*, *11*(17), 10911-10922.

Wilson, S. (2013). "The flipped class: A method to address the challenges of an undergraduate statistics course." *Teaching of Psychology*, *40*(3), 193-199.

Yarbro, J., Arfstrom, K. M., McKnight. K., & McKnight, P. (2014, June). Extension of a review of flipped learning. Retrieved June 6, 2017, from https://www.pearson.com/content/dam/one-dot-com/one-dot-com/global/Files/efficacy-and-research/he/fl-613_A023_FlippedLearning_2014_JUNE_SinglePage_f.pdf

Zengin, I. (2017). Investigating the Use of the Khan Academy and Mathematics Software with a Flipped Classroom Approach in Mathematics Teaching. *Educational Technology & Society*, *20*(2), 89–100.

Zhukovskiy, V. E. (2017). Study of network technologies in the "flipped class". *Proceedings of the IV International Scientific and Methodological Conference,* Saint-Petersburg, Russia: Saint-Petersburg Mining University, 1, 16-24.

http://www.ejmste.com