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STUDENTS AND DIGITAL MATHEMATICS TEACHING[1]

Assoc. Prof. Ion Mierlus-Mazilu, PhD
Department of Matematics and Computer Science
Faculty of Civil, Industrial and Agricultural Buildings
Technical University of Civil Engineering Bucharest, Romania
Phone: +40 212 421 208
E-mail: mmi@utcb.ro

Assoc. Prof. Emilia Velikova, PhD
Department of Matematics
Faculty of Natural Scoences and Education
"Angel Kanchev" Univesity of Ruse
Phone: +359-885 635 874
E-mail: evelikova@uni-ruse.bg

Assist. Prof. Ralitsa Vasileva-Ivanova, PhD
Department of Matematics
Faculty of Natural Scoences and Education
"Angel Kanchev" Univesity of Ruse
Phone: +359-887 395 464
E-mail: rivanova@uni-ruse.bg

Abstract: *Mathematics plays one of the most important roles in developments of our modern and technology-centered society. Additionally, it lays the basis for technical studies, but is also needed e.g. in economics and life science. In fact, good mathematical skills are crucial for science and economy. Unfortunately, various studies have shown that mathematical competence in Europe has weakened in recent decades. The lack of mathematical proficiency is already causing problems in engineering mathematics' and other courses in European HEIs. In fact, this seems to be a global problem, and e.g. the learning outcomes of Eastern European countries have been weaker than expected, especially in mathematics, after they moved to the Western European model of education* (*e.g. SEFI 2002*). *Compounding the issues, the resources allocated to teaching have been decreased so that there are fewer resources for teaching and the development of teaching.*

Additionally, in recent years the study groups have been increasing and becoming even more heterogeneous. This naturally causes problems for organization of mathematics' teaching as for example the entry level of competence in mathematics (*RulesMath project study this problem*) *varies greatly depending on the background studies. Under these circumstances, taking into account individual needs or organizing dynamic and creative activities becomes almost impossible during the classroom sessions. As a sum of many factors, it has been reported that the drop-out rates are high in the field of technology.*

In this paper, we will present the learning resources developed within the FutureMath project and how materials developed within this project are used by students in our universities and their positive influence in the process of teaching and learning mathematics.

Keywords: *Innovative Pedagogical Methods, Digitalization, Engineering Mathematics Education.*

INTRODUCTION

Mathematical skills are a prerequisite in technical studies and mathematics lay the basis for understanding different engineering disciplines. Thus, the students' poor skills in mathematics slow down or even prevent their studies. In principle, an engineer must be able to think analytically and to be capable of logical reasoning. In addition, an engineer needs to understand mathematics,

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which allows them to deal with and understand technical problems (Rahman, 2012; Zwart et al., 2017). Overall, mathematics penetrates deep into the engineering professional field, affecting the opportunities to absorb and learn engineering subjects. Thus, for example to be able to make new technological innovations, the understanding and skills of mathematics are crucial.

Unfortunately, the lack of basic skills and knowledge of mathematics among the European engineering students complicates and in the worst case, even prevents future technological development in Europe. In order to maintain the competitiveness of Europe, the basic level of mathematical proficiency needs urgently to be increased on a large scale. Based on above described situation, the proposed project aims to improve the mathematical proficiency of European engineering students by developing methods and best practices to learn, teach and assess mathematics effectively. Since the objectives of the project are international, the best results can be achieved with transnational co-operation. Based on the results of a survey collected in our universites, students expect more digital learning possibilities and utilizations of ubiquitous technology in mathematics' studies. This is very natural as the whole of society is changing. Big data, open data, cloud services, digitalization, IoT etc. affect society and social activities on a large scale. As working life is constantly changing, its expectations and requirements have become more diverse. The 21st century skills, such as collective thinking, collaboration, creativity and shared problem solving skills are key components in modern working life and therefore the university teaching and learning should also train these skills (Goos, 2010; Drijvers, 2013, p. 2).

The FutureMath project aims to respond to the requirements of modern society and to make mathematics' learning and teaching more digitalized, effective and accessible. Additionally, the aim is to explore and develop the most motivational, learner centered methods, techniques and resources for engineering mathematics learning and teaching with the help of technology. All the learning resources developed in the project will be made available for free under the idea of Open Source or Open Educational Resource (OER).

Overall, the project respects and enables i.e. collective thinking, collaboration and shared problem solving skills. The project aims to develop and improve technology-enhanced methods and resources to teach, learn and study engineering mathematics under the themes such as collaboration, peer instruction and assessment, mostly based on approaches of e-learning 2.0 and 21st century skills.

EXPOSITION

Innovative pedagogical methods and techniques

The **FutureMath** project develops pedagogical methods and resources to teach and learn mathematics more effectively by providing personalized learning possibilities with the help of ubiquitous technology. The underlying notion is to support digitalization of European engineering mathematics education in a large scale. By these means, it is supposed to improve the efficiency, accessibility and quality of mathematics teaching and learning on European level which, in fact, is one of the four common objectives of EU's Strategic Framework of Education and Training 2020. Additionally, as an impact of the project, improving of transversal and basic skills (ET2020), such as digital skills and mathematical skills, will be a central focus. With these actions, it is expected not only to develop innovative learning approaches but also to enrich the teaching, support pesonalized learning and increase the flexibility and attractiveness.

In addition to the mathematics learning platform (MLP), the proposed project aims to develop innovative pedagogical methods, techniques, materials and resources not only to teach and learn mathematics but also to assess mathematics' learning. The key approaches while planning the resources are i.e. collective thinking, collaboration and shared problem solving skills - the skills that are necessary for success in working life. Furthermore project resources will respect individual learning solutions. Therefore, different learning types will be taken into account in the project's material production. In this way, it is also possible to decrease the inequality among different kinds of learners.

Overall, the one main objective of this project is to increase the global large-scale awareness about the possibilities ubiquitous technology offers for mathematics learning throughout MLP (Fig. 1).

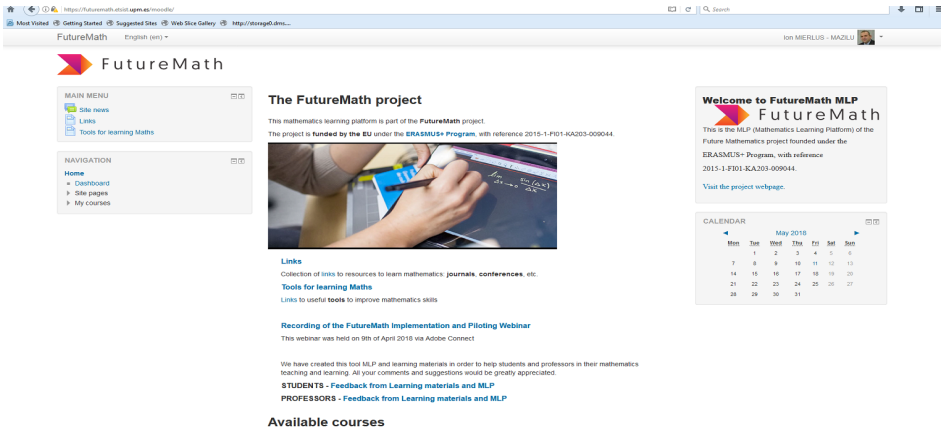


Fig. 1. MLP

Our aim is to make mathematics learning more motivational, interesting and increase accessibility and the alternative modern methods for mathematics learning.

MLP - materials and resources

The materials developed within the project aim to:

- Offer a generous database of resources for learning and teaching mathematics. The materials are short videos, interactive materials, stack exercises and quizzes. They offer theoretical explanations, worked examples, visualization of abstract mathematical problems or concepts, and the possibility to test your own knowledge.
- Encourage self-paced learning. Besides being flexible and convenient, online materials are available anytime, so students can access their course information any time of the day and as many times as they feel the need to do so. Another advantage is that students who work at a fast pace have the opportunity to gain competences quickly, while the others, who learn at a slower pace, have the opportunity to review materials.
- Develop mathematical visualization skills. The use of computers enables learners to manipulate diagrams dynamically. This not only supports learning by visualizing actual diagrams, graphs or methods of solving problems, it also encourages learners to make connections between abstract mathematical notions and real life problems.
- Encourage the search of connections. The computer enables formulae, tables of numbers and graphs to be linked. Making changes in one representation and seeing changes in the others helps students to better understand the connections between them. Working through a medium which enables learners to switch effortlessly between these representations enhances their conceptual development.
- Observing patterns. When exploring certain mathematical problems, the speed of computers and computer programs enables students to produce many similar examples. This supports their observation of patterns. As a consequence, it encourages them to make their own conjectures and to test them out (eventually modifying their ideas if it is the case) Also this supports and justify the generalizations in different mathematical problems.
- Learning from feedback. The computer quizzes provide a fast and reliable feedback which is impartial. This can encourage students to test their knowledge and improve it, if necessary.

Most of the materials developed in the project are in the subjects: Algebra, Analysis and Geometry (Fig. 2).

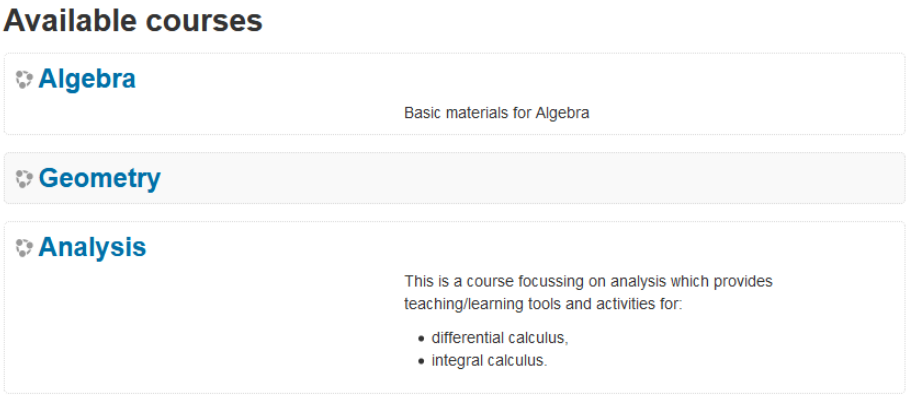


Fig. 2. MLP Available courses

Each course has a large content of materials presented in different way.
Looking at the Analysis course (Fig. 3) we can see that our MLP cover almost all subjects:

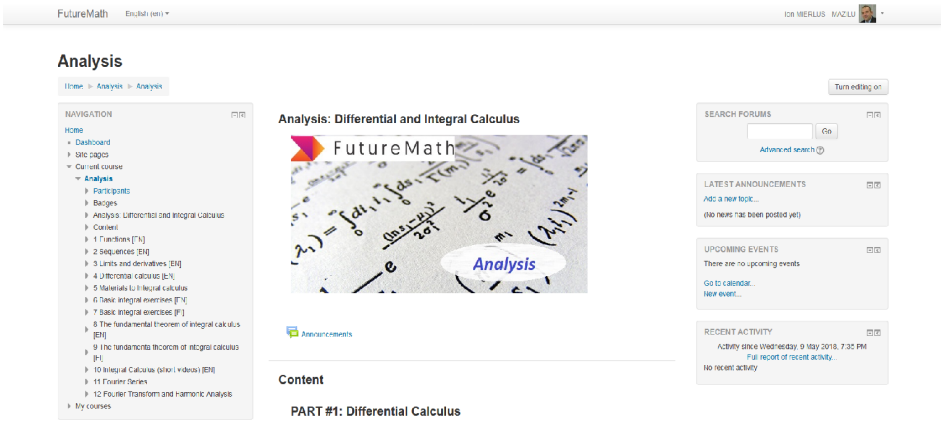
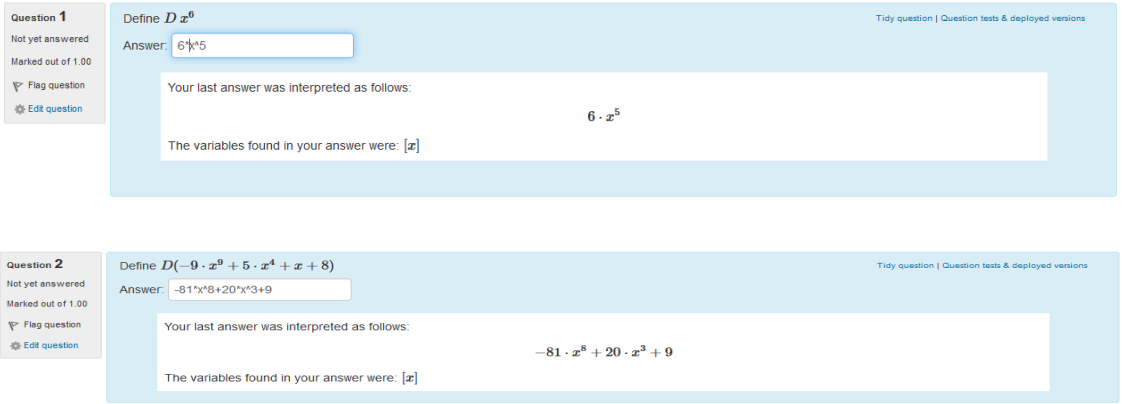


Fig. 3. MLP Analysis cours

The types of the materials in our MLP are:

- STACK - System for Teaching and Assessment using a Computer algebra Kernel it's an Open-source system functions in Moodle, based on Maxima commands and LaTeX, Automatic assessment of the mathematical exercises (Fig. 4)



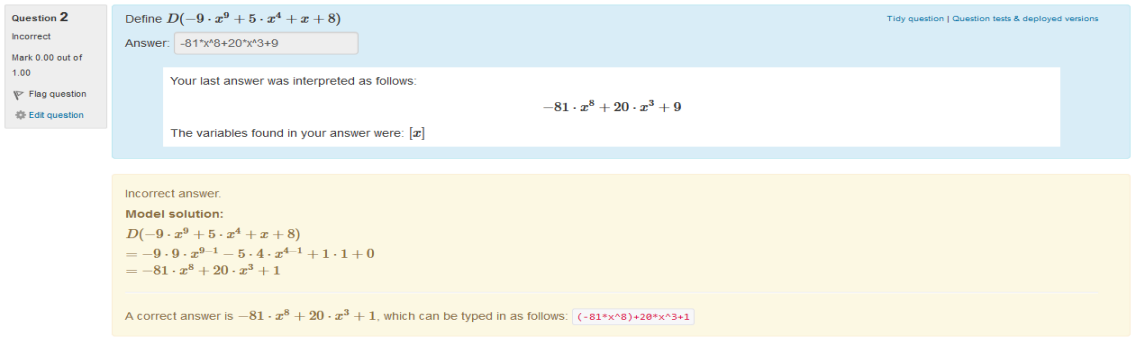


Fig. 4. MLP STACK exercices

- VIDEO (Fig. 5) Videos can be an effective teaching aid in the classroom for any discipline. With regard to videos on mathematics, at the beginning of the eighties they had a dense structure, developing their contents in a rigid way, with the result that the interaction with the students was not favoured. Nevertheless, this is very different nowadays. So, the teacher, on using videos as educational resources, must consider a work methodology suitable for extracting all those educational possibilities.

When videos are specifically used, in a particular context of the curricular design, they can acquire a different meaning from the one expected by their authors. In this way, one must bear in mind that the students will normally tend to passivity when watching TV and movies; therefore, it is of fundamental importance to carry out some activities previously prepared, in order to eliminate this risk of passivity and to get from these aids something more than a simple entertainment.

If a video is considered as an educational resource, one must look for those contexts in which it is possible that the students - and the teachers also - interact with that video. That is to say, it is necessary to devise curricular designs in which, in the sequence of programmed activities, the way of watching the video and the moments to do other collateral activities will be perfectly defined.

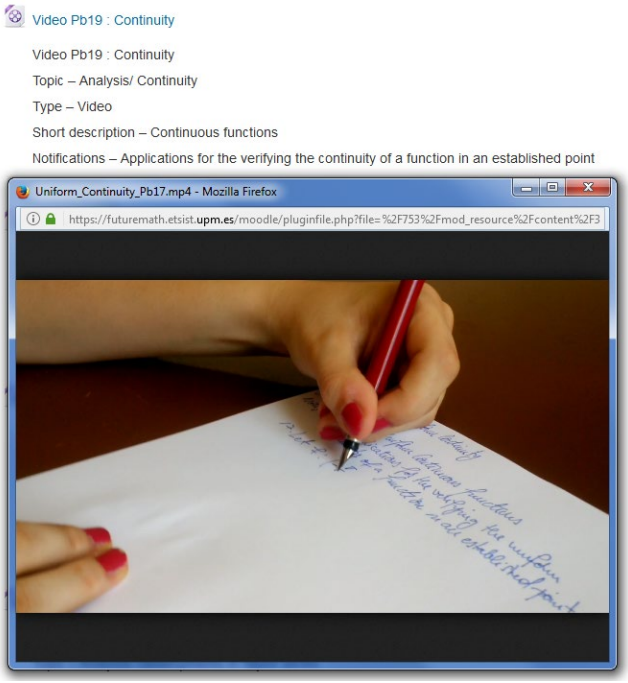


Fig. 5. MLP STACK exercices

- GEOGEBRA - GeoGebra is a Dynamic Mathematics Software (DMS) for teaching and learning mathematics at all levels of education that brings together geometry, algebra, spreadsheets, graphing, statistics and calculus in one easy-to-use package. GeoGebra is a rapidly

expanding community of millions of users located in just about every country. GeoGebra has become the leading provider of dynamic mathematics software, supporting science, technology, engineering and mathematics (STEM) education and innovations in teaching and learning worldwide. It is as easy to use as Dynamic Geometry Software (DGS) but also provides basic features of Computer Algebra Systems (CAS) to bridge some gaps between geometry, algebra and calculus.

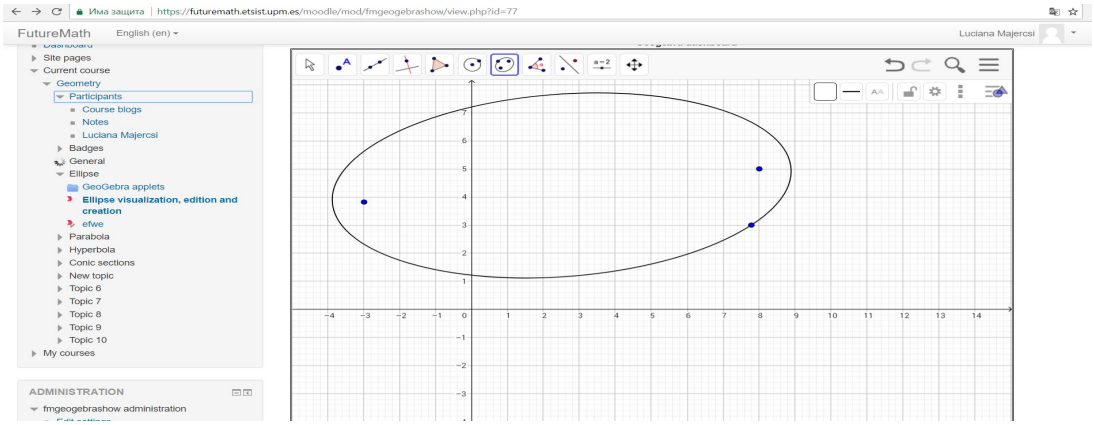


Fig. 6. MLP GEOGEBRA online work

GeoGebra is open source software under the GNU General Public License and freely available at www.geogebra.org. There, you can either download installers for multiple platforms or launch the software directly from the Internet using GeoGebra Web Start.

Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student's learning.

GeoGebra was created to help students gain a better understanding of mathematics. You can use it for active and problem-oriented teaching, it fosters mathematical experiments and discoveries both in classroom and at home.

Geogebra can be used in online work (Fig. 6), applet usage (Fig. 7) and also for self traniang (Fig. 8)

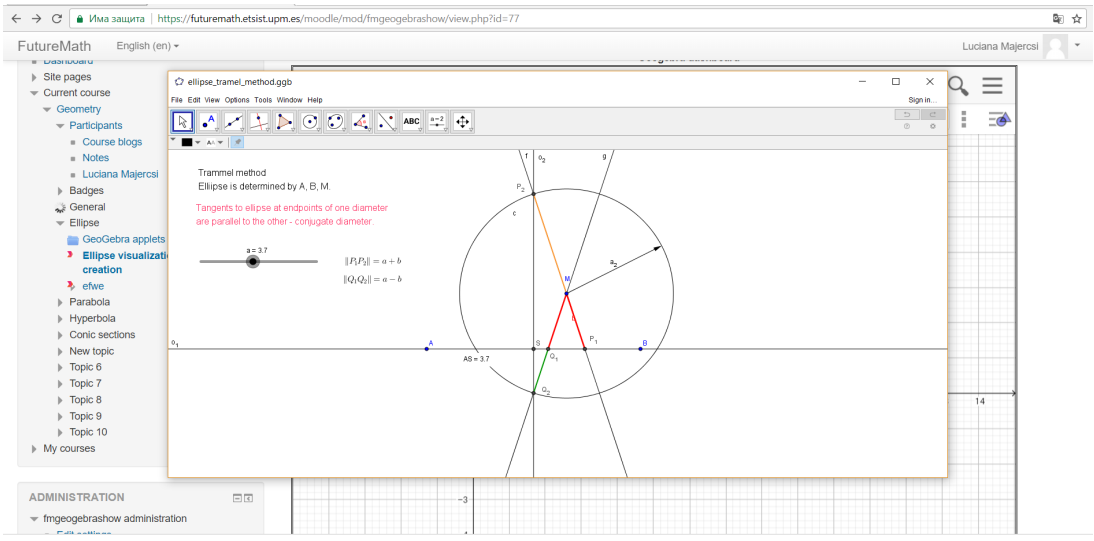


Fig. 7. MLP GEOGEBRA applet usage

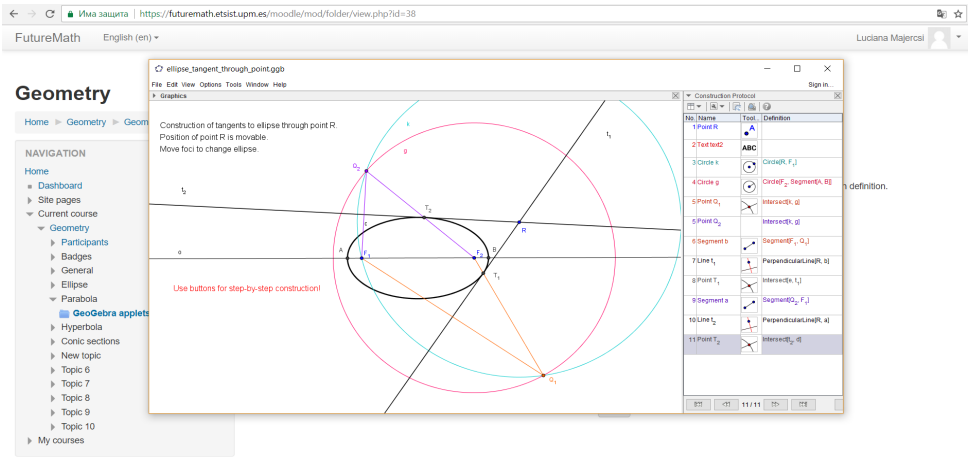


Fig. 8. MLP GEOGEBRA online work

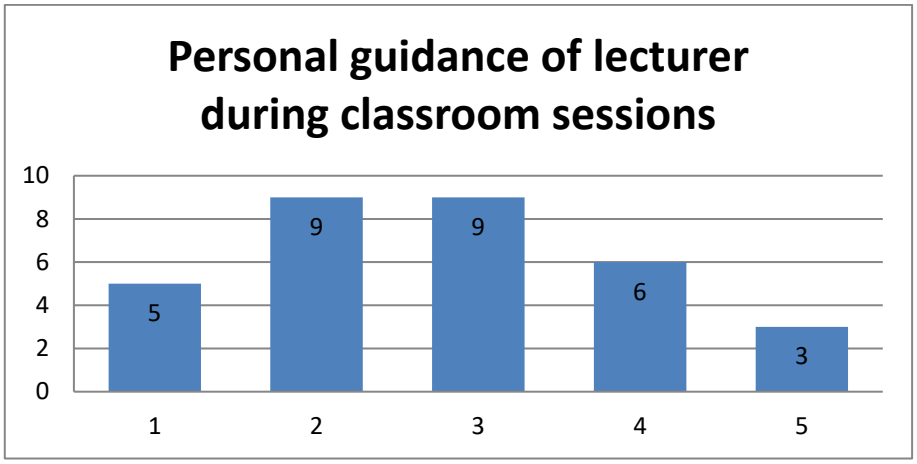
Students and digital Mathematics Teaching

The material was given directly to the students. All the students from are push to use the materials and to learn using the materials. In this way, we will test the materials from our MLP.

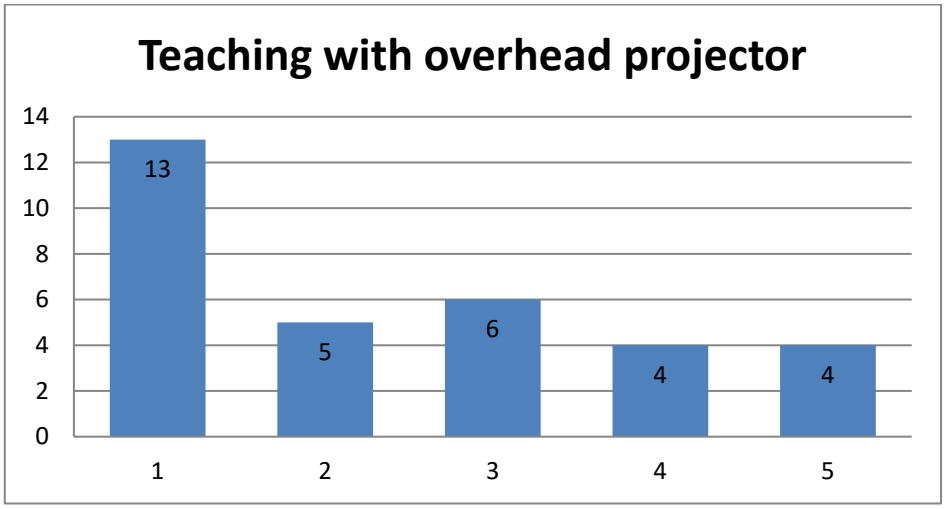
In the end of the course, we give to the students a questionnaire and in this way, they can provide feedback from the materials from our MLP.

In this way, at the question "select five methods, that are the most important for you in terms of learning. Mark down numbers 1-5. (1=the most important, 5=the fifth most important)":

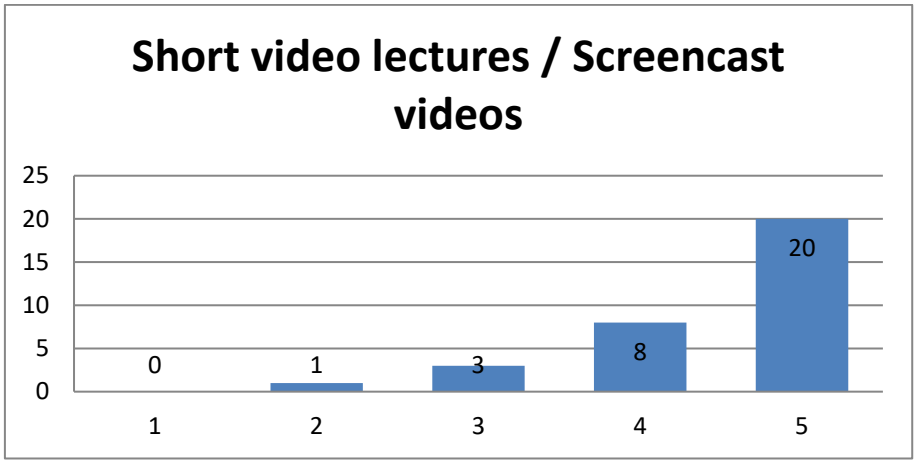
- Personal guidance of lecturer during classroom sessions:



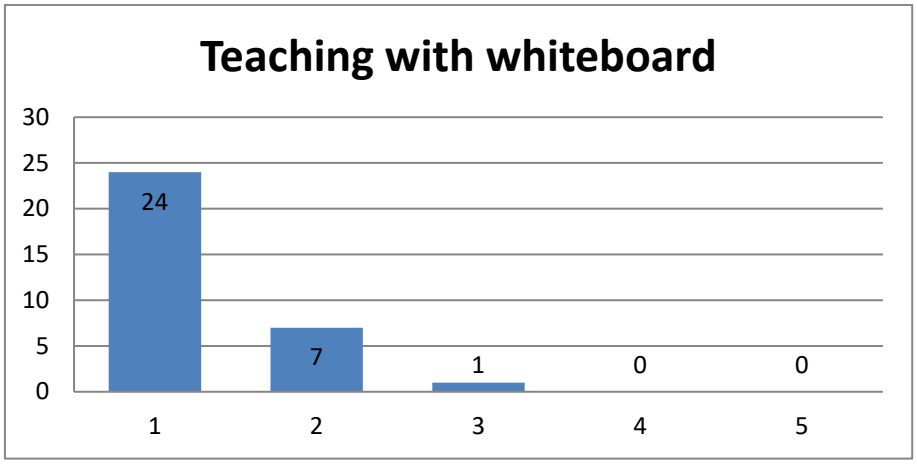
- Teaching with overhead projector



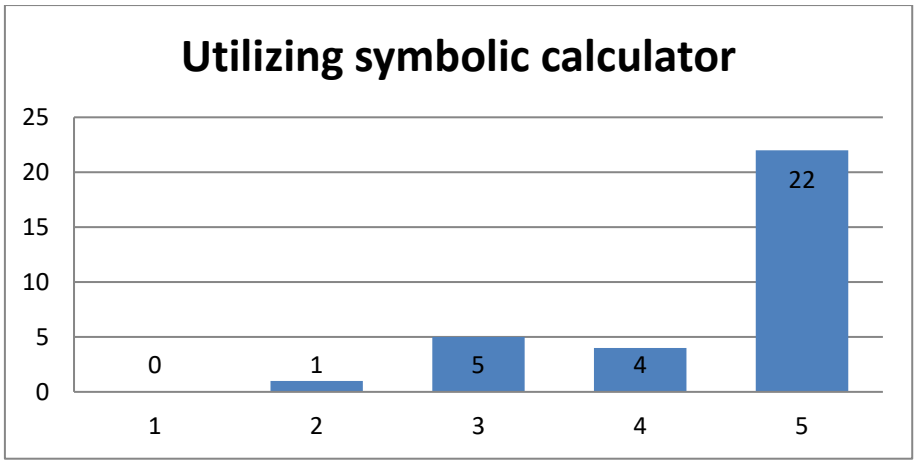
- Short video lectures / Screencast videos



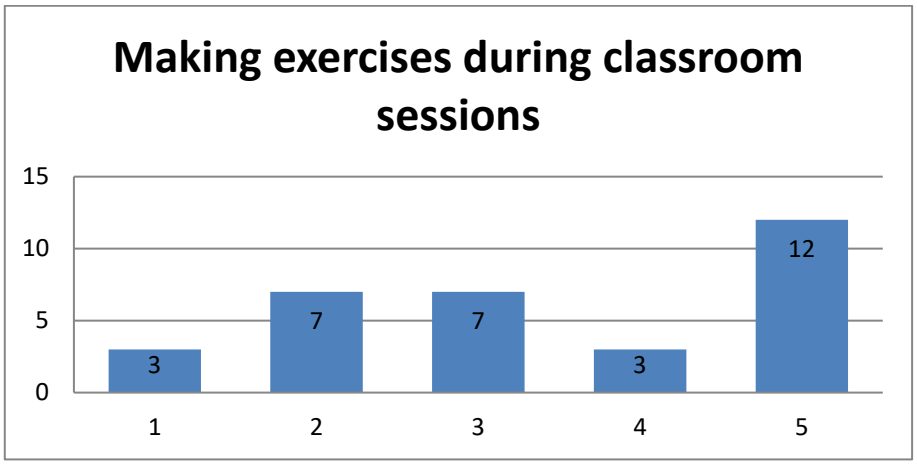
- Teaching with whiteboard



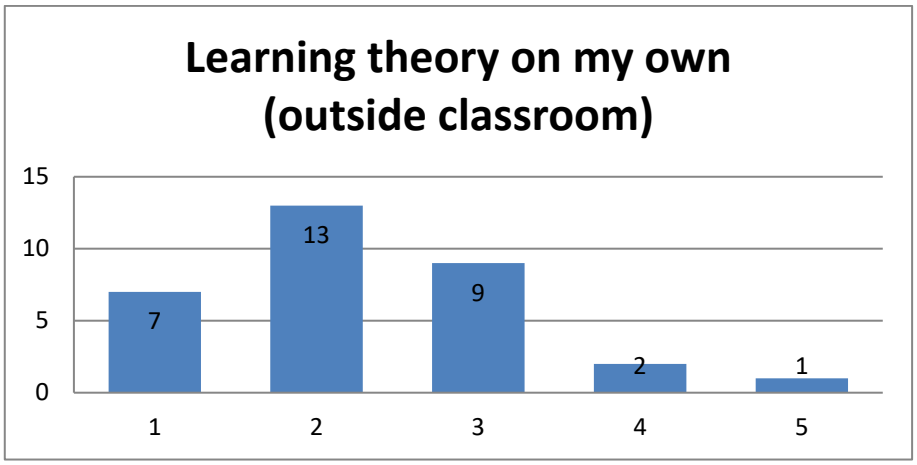
- Utilizing symbolic calculator



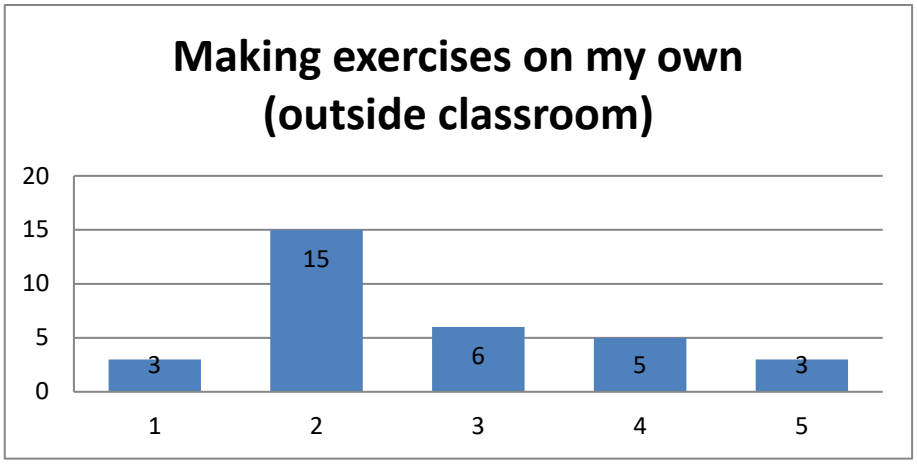
- Making exercises during classroom sessions



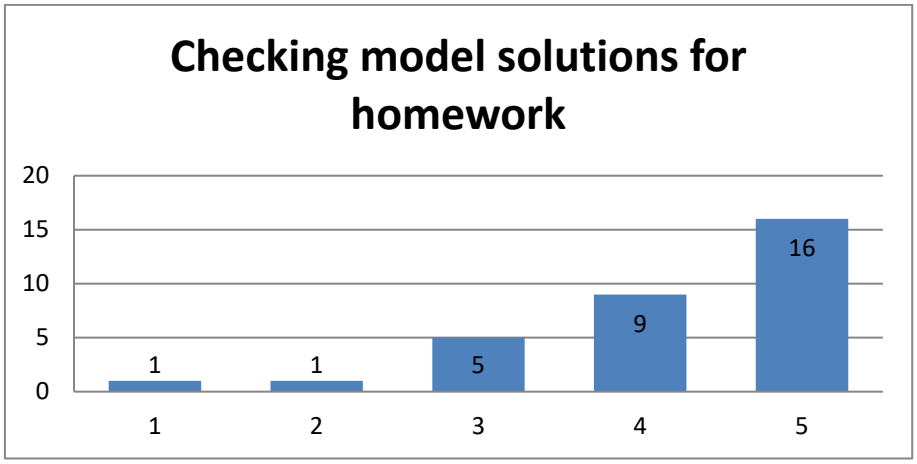
- Learning theory on my own (outside classroom)



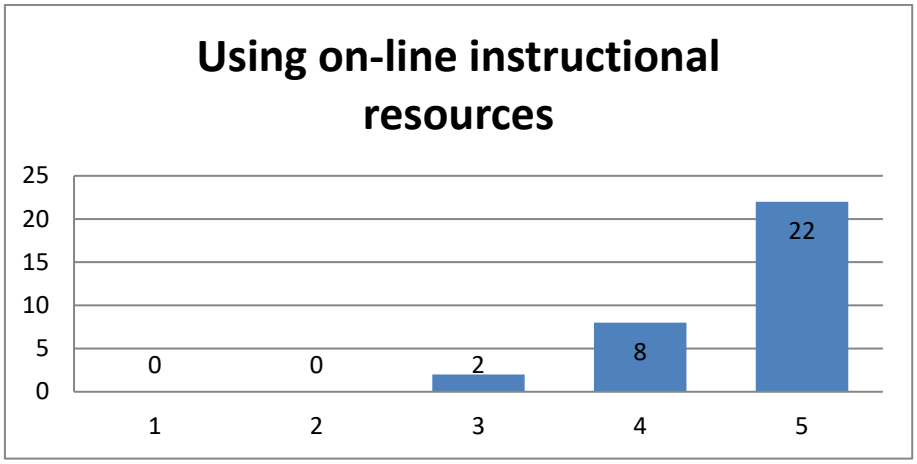
- Making exercises on my own (outside classroom)



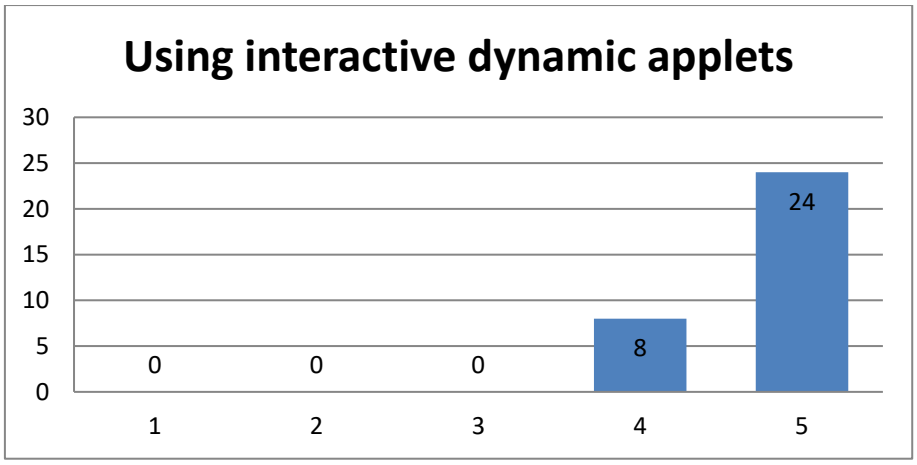
- Checking model solutions for homework



- Using on-line instructional resources

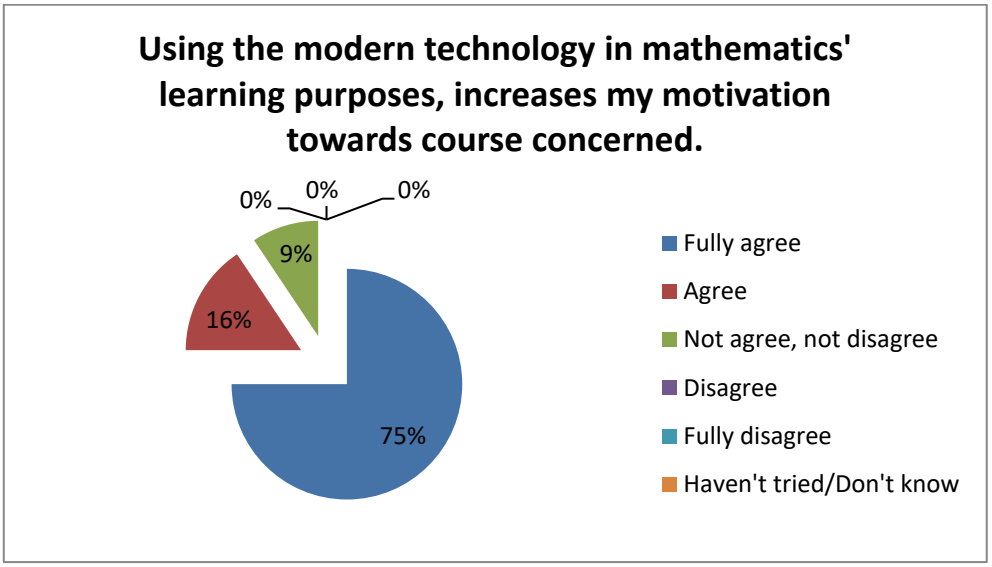


- Using interactive dynamic applets

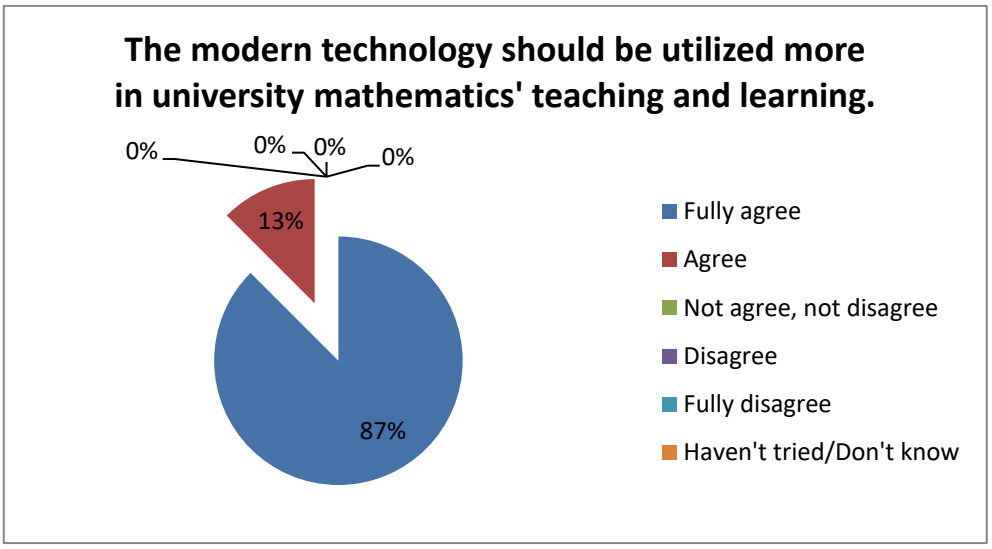


Asking the students "For the following statements, select the option that represents your opinion the most" we obtain:

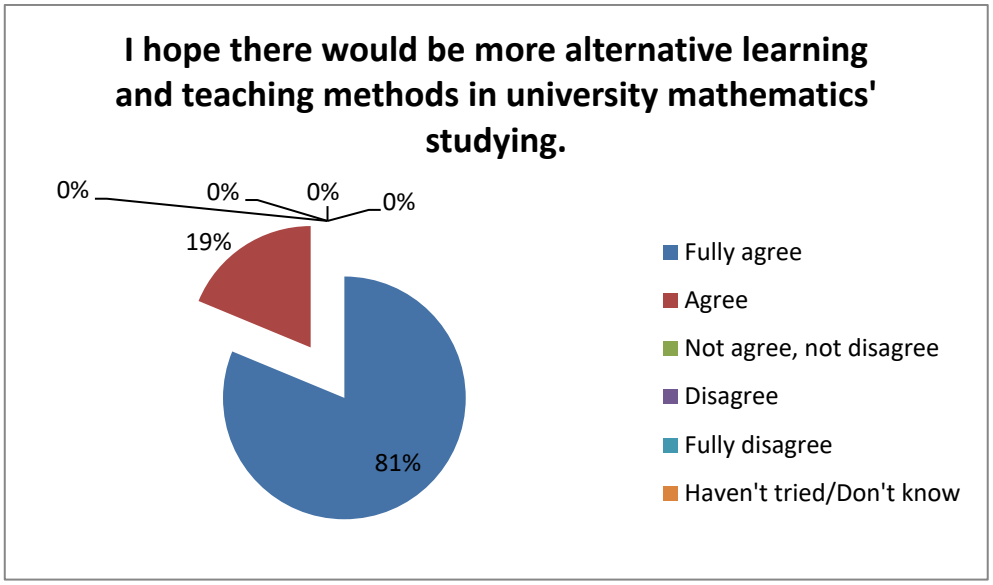
- Using the modern technology in mathematics' learning purposes, increases my motivation towards course concerned.



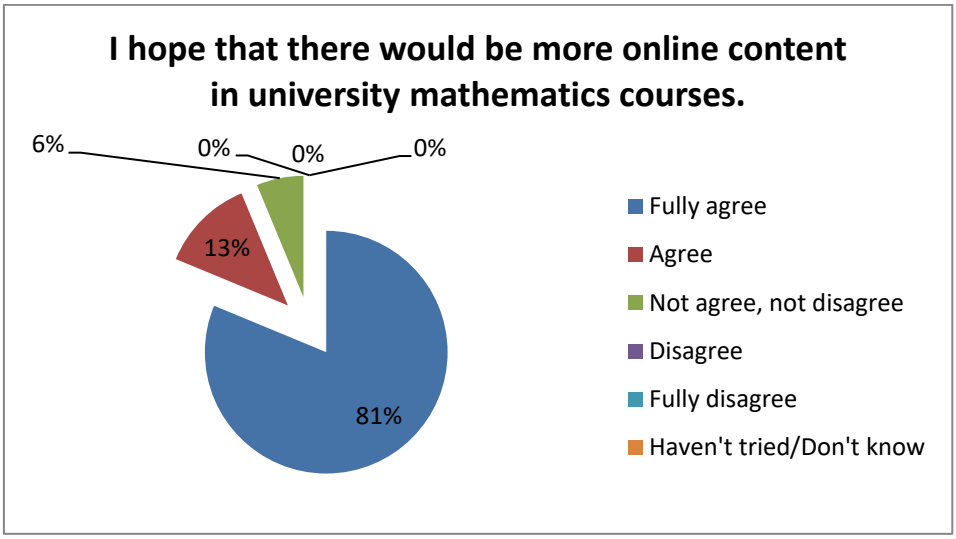
- The modern technology should be utilized more in university mathematics' teaching and learning.



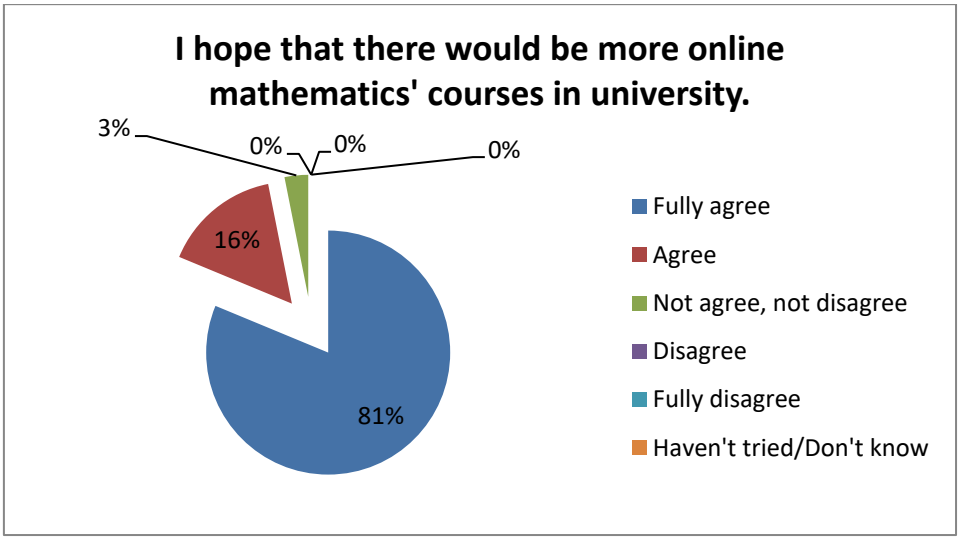
- I hope there would be more alternative learning and teaching methods in university mathematics' studying.



- I hope that there would be more online content in university mathematics courses.



- I hope that there would be more online mathematics' courses in university.



CONCLUSION

The students from our universities, needs more online materials, they like the idea of learning using MLP, using modern tools. We hope that our project, our MLP will be a good start for them and alos help them a lot.

REFERENCES

Drijvers, P. (2013). Digital technology in mathematics education: why it works (or doesn't). PNA, 8(1), 1-20.

Goos, M. (2010). Using technology to support effective mathematics teaching and learning: What counts? Research Conference 2010, pp. 67-70, URL: https://research.acer.edu.au/cgi/-viewcontent.cgi?article=1067&context=research_conference , (Accessed on 21.09.2018).

Rahman, A. (2012). Improving the Teaching of Engineering Mathematics using Action Research, ELSEVIER Procedia - Social and Behavioral Sciences, Vol. 56, Pages 483-493

Zwart, D. et al. (2017). The effects of digital learning material on students' mathematics learning in vocational education, Professional Education & Training Research Article, 10 p., URL: https://www.tandfonline.com/doi/pdf/10.1080/2331186X.2017.1313581?needAccess=true (Accessed on 25.09.2018).

http://www.futuremath.eu/index.php/en/

