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FUTUREMATH PROJECT - INNOVATIVE PEDAGOGICAL METHODS, TECHNIQUES, MATERIALS AND RESOURCES

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Abstract: Mathematics is one of the key subjects for any career in engineering, science or business. Yet, over the years, the process of teaching mathematics has faced more and more challenges and poorer performances. One reason behind these results is the significant number of changes taking place in the last two decades. The rapid development of technology is one of the changes that have profoundly influenced the teaching of mathematics at the university level. The considerable differences among the mathematical knowledge and skills of students, as well as the differences in their ability to learn mathematics, are also important factors. The approach of FutureMath project is to take into account all of these factors in order to create a framework suitable for individual and self-paced learning.

FutureMath project started from the need of high quality mathematics' education in an era of technology and computers. The goal of the project is to make mathematics learning more motivational, interesting, effective and accessible. The project aims to develop technology-based innovative pedagogical methods, techniques, materials and resources, for teaching and learning mathematics, and for assessing mathematics' learning [1]. The learning resources developed within the project had to pay attention to different learner types, effective feedback and assessment. They offer alternative modern methods for mathematics learning, individual learning solutions and flexibility. All the learning resources developed within the project will be made available for free under the idea of Open Source or Open Educational Resource (OER) at the end of the project [1]. Some of the materials developed within this project are already used in the partner universities and their influence in the process of teaching and learning mathematics is a positive one.

In this paper we will present the learning resources developed within the project and how some of the materials developed within this project are already used in the partner universities and their positive influence in the process of teaching and learning mathematics.

Keywords: Innovative Pedagogical Methods, Digitalization, Engineering Mathematics Education

INTRODUCTION

Mathematics is one of the key subjects for any career in engineering, science or business and a good mathematical knowledge is required for understanding and mastering different engineering disciplines. Unfortunately, in the recent decades, the mathematical competences of students have

weakened and all those involved in teaching mathematics are facing more and more challenges. There are several factors that had a substantial impact on the process of teaching mathematics.

The rapid development of technology and computer programs is one of them. There is a wide variety of mathematical computer software (Maple, Mathematica, Mathcad, Matlab etc.) that can offer quick and easy solutions to different kind of mathematical or engineering problems. Spreadsheet programs, such as Excel, also support complex calculations through their complex library of functions. On one hand, these tools are important in solving different kind of problems, but on the other hand, they may be one cause of low students' motivation on acquiring substantial mathematical knowledge.

Another factor that is causing difficulties in the process of teaching mathematics at university level is that the study groups are large and becoming more heterogeneous in recent years. As the students' background studies and level of competence in mathematics varies greatly, the organization of the teaching process becomes difficult. In these circumstances, taking into account the individual needs of students or organizing dynamic and insightful activities becomes almost impossible during conventional classes.

A meaningful and efficient process of teaching mathematics has to take into account all the factors who have a substantial impact on the process. The new ways of teaching must rely on technology to create flexible and friendly learning environments in which students can easily acquire and understand new information. Also, the existing technology must be used to its fullest potential to solve a wide variety of problems, make connection between math problems and real life situations and enhance the quality of learning. The teachers must encourage deeper knowledge through geometric exploration programs where learners can visualize functions and data, and experiment with mathematical formulas.

TRENDS IN HIGHER EDUCATION

Chris Parr in his article “6 trends that will accelerate the adoption of technology in higher education” (Parr, 2014) takes a look at the six “key trends” picked out in the NMC Horizon Report: 2014 Higher Education Edition that are accelerating the adoption of technology in higher education. The report, aims to examine emerging technologies for their potential impact on and use in teaching and learning within higher education settings. It is divided by three trends’ categories due to the temporal significance (Johnson, L., Adams Becker, S., Estrada, V., Freeman, A., 2014):

- fast trend - driving changes in higher education over the next one to two years;
- mid-range trend - driving changes in higher education within three to five years;
- long-range trend - driving changes in higher education in five or more years.

FAST TREND

“The top 25 social media platforms worldwide share 6.3 billion accounts among them,” the Horizon report says. “Educators, students, alumni, and the general public routinely use social media to share news about scientific and other developments. The impact of these changes in scholarly communication and on the credibility of information remains to be seen, but it is clear that social media has found significant traction in almost every education sector.”

For educational institutions, social media enable “two way dialogues between students, prospective students, educators, and the institution that are less formal than with other media”, it continues, adding that educators are using them “as professional communities of practice, as learning communities, and as a platform to share interesting stories about topics students are studying in class”.

According to Horizon Report 2014 Higher Education Edition, “education paradigms are shifting to include more online learning, blended and hybrid learning, and collaborative models”.

Institutions that “embrace face-to-face, online and hybrid learning models” have the potential to engage with students who “already spend much of their free time on the internet”, learning and exchanging new information.

“An increasing number of universities are incorporating online environments into courses of all kinds, which is making the content more dynamic, flexible, and accessible to a larger number of students,” the report says. “To encourage collaboration and reinforce real world skills, universities are experimenting with policies that allow for more freedom in interactions between students when working on projects and assessments.”

MID-RANGE TREND

“There is a growing interest in using new sources of data for personalizing the learning experience and for performance measurement,” the Horizon report says. “As learners participate in online activities, they leave an increasingly clear trail of analytics data that can be mined for insights.”

The report concludes that although students and educators are generating more and more data, especially in online environments, “higher education in general has yet to fully embrace these sorts of processes”.

“There is a growing interest in developing tools and algorithms for revealing patterns inherent in those data and then applying them to the improvement of instructional systems,” it says.

Pedagogical practice on university campuses all over the world is shifting, as students learn “by making and creating rather than from the simple consumption of content”, Horizon Report: 2014 Higher Education Edition says.

“University departments in areas that have not traditionally had lab or hands-on components are shifting to incorporate hands-on learning experiences as an integral part of the curriculum. Courses and degree plans across all disciplines at institutions are in the process of changing to reflect the importance of media creation, design, and entrepreneurship.”

New funding mechanisms have “put university students more in control of the development of their research than ever before”, the report continues.

“Through the crowdfunding websites like Kickstarter or Indiegogo, student-led projects that might have stalled at the concept or model stage can now be brought to fruition. A student at Cornell University, for example, is using Kickstarter to develop Kicksat (Manchester, 2011), a project intended to launch a small spacecraft into low earth orbit.” In another example, at Dartmouth College, researchers are exploring how student-generated video can be used to “further learning and evaluate a student’s academic performance through the collection of various assignments housed on the Media Projects page (Simon, 2013) of the college’s website”.

LONG-RANGE TREND

According to the Horizon report, there is “a growing consensus among many higher education thought leaders”.

Such models “use technology as a catalyst for promoting a culture of innovation in a more widespread, cost-effective manner”, and pilots that are being developed for higher education institutions include the improvements of organizational structures to “more effectively nurture entrepreneurship among both students and faculty”

There has been a shift in the perception of online learning to the point where it is seen as a viable alternative to some forms of face-to-face learning”, the Horizon Report says. “The value that online learning offers is now well understood, with flexibility, ease of access, and the integration of sophisticated multimedia and technologies chief among the list of appeals.”

Developments in learning analytics and “a combination of cutting-edge asynchronous and synchronous tools” will continue to advance the state of online learning and keep it compelling, it continues, “though many of these are still the subjects of experiments and research by online learning providers and higher education institutions”.

According to the 56-strong panel of experts that were consulted for the report, the advent of voice and video tools is “not only increasing the number of interactive activities between online instructors and students, but also greatly improving their quality”, while audio tools “such as VoiceThread and SoundCloud, along with video creation tools such as iMovie and Dropcam, enable faculty to capture important human gestures, including voice, eye contact, and body language, which all foster an unspoken connection with learners.”

FUTUREMATH PROJECT: GOAL AND INNOVATION

FutureMath project started from the need of high quality mathematics' education in an era of technology and computers. The goal of the project is to make mathematics learning more motivational, interesting, effective and accessible. The project aims to develop technology-based innovative pedagogical methods, techniques, materials and resources, for teaching and learning mathematics, and also for assessing mathematics' learning [1]. The learning resources developed within the project had to pay attention to different learner types, effective feedback and assessment. They offer alternative modern methods for mathematics learning, individual learning solutions and flexibility.

All the learning resources developed within the project will be made available for free under the idea of Open Source or Open Educational Resource (OER) at the end of the project [1].

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 personalized 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. Our aim is to make mathematics learning more motivational, interesting and increase accessibility and the alternative modern methods for mathematics learning [1].

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NEED ANALYSIS

To collect information on existing mathematics education at European technical universities the needs analysis survey was done.

The needs analysis was made to clear up, what is the point of view of students about the future of mathematics.

The need analysis was done in all partners universities in FutureMath project and also in “Angel Kanchev” University of Ruse, Faculty of Natural Sciences and Education, Department of Mathematics.

And with the help of the needs analysis results and "A Competence-based Framework for Mathematics Curricula in European Engineering Education" SEFI 2013 publication give us guidelines for the planning and implementation phases of the project.

The follow questioner was applied (online) to the students:

<https://lomake.tamk.fi/v3/lomakkeet/19758/lomake.html>

Background

Age	<input type="text"/>
Gender	Female <input type="button" value="▼"/>
University	TUCEB <input type="button" value="▼"/>
Degree programme	<input type="text"/>
Background studies	High school <input type="button" value="▼"/>
I have a smartphone	Yes <input type="button" value="▼"/>
I have a tablet	Yes <input type="button" value="▼"/>
I have a computer	Yes <input type="button" value="▼"/>

Teaching and learning methods in mathematics context

What do you think is meant
by modern teaching and
learning methods in
mathematics' context?

Select which teaching method you perceive as modern (select all you agree)

- Teaching with transparencies and overhead projector
- Teaching with computer presentations using dataprojector
- Using short teaching videos/screencasts
- Writing on whiteboard
- Utilizing smartphones/tablets in learning purposes
- Utilizing symbolic calculator
- Operating in Moodle or other learning environment
- Making notes
- Teaching using dynamic mathematical software applets
- Working in groups
- Use of simulations/demos
- Use of virtual labs
- Other

Reports Awarded with "Best Paper" Crystal Prize'17

If other, please specify.

Which teaching methods are being/have been used in your university mathematics' courses?

- Teaching with transparencies
- Teaching with slides and overhead projector
- Using short teaching videos/screencasts
- Writing on whiteboard/blackboard
- Utilizing smartphones/tablets in learning purposes
- Utilizing symbolic calculator
- Operating in Moodle or other learning environment
- Making notes
- Use of virtual labs
- Other

If other, please specify.

I have utilized short videos/screencasts in mathematics' learning.

Yes, my teacher provides short videos

If you replied that your teacher doesn't provide, but you have used videos, where did you find videos?

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 | <input type="checkbox"/> |
| Teaching with overhead projector | <input type="checkbox"/> |
| Short video lectures / Screencast videos | <input type="checkbox"/> |
| Teaching with whiteboard | <input type="checkbox"/> |
| Utilizing symbolic calculator | <input type="checkbox"/> |
| Making exercises during classroom sessions | <input type="checkbox"/> |
| Learning theory on my own (outside classroom) | <input type="checkbox"/> |
| Making exercises on my own (outside classroom) | <input type="checkbox"/> |
| Checking model solutions for homework | <input type="checkbox"/> |
| Using on-line instructional resources | <input type="checkbox"/> |
| Using interactive dynamic applets | <input type="checkbox"/> |

For the following statements, select the option that represents your opinion the most.

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

Fully agree

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

Fully agree

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

Fully agree

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

Fully agree

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

Fully agree

Proceed

Looking at the answers we can see the what students expect from our project.

Which teaching methods are being/have been used in your university mathematics' courses?

- Writing on whiteboard/blackboard
- Making notes
- Teaching with transparencies
- Teaching with slides and overhead projector

Select which teaching method you perceive as modern (select all you agree)

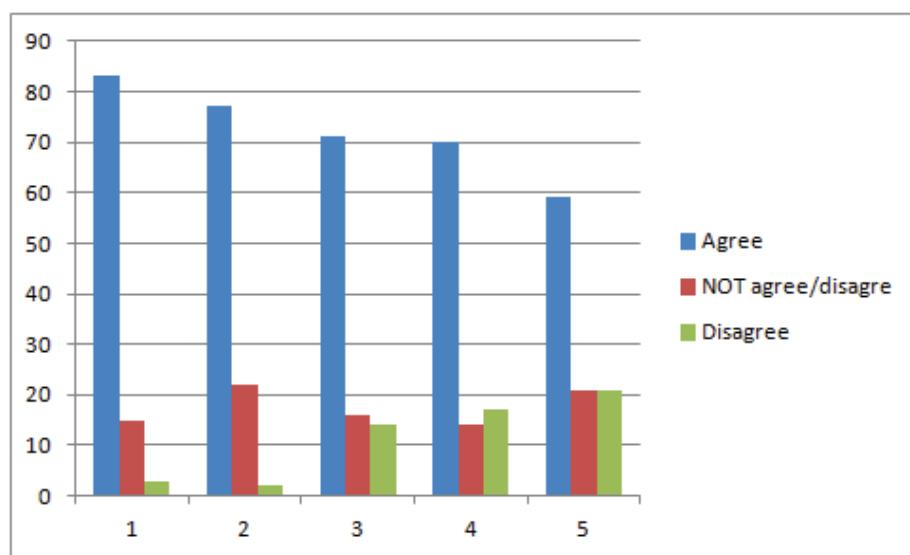
- Operating in Moodle or other learning environment
- Utilizing smartphones/tablets in learning purposes
- Teaching using dynamic mathematical software applets
- Working in groups
- Use of simulations/demos
- Use of virtual labs
- Utilizing symbolic calculator
- Teaching with transparencies and overhead projector
- Teaching with computer presentations using dataprojector
- Using short teaching videos/screencasts

Select five methods, that are the most important for you in terms of learning.

- Making exercises during classroom sessions
- Personal guidance of lecturer during classroom sessions
- Teaching with overhead projector
- Short video lectures / Screencast videos
- Utilizing symbolic calculator
- Using on-line instructional resources
- Using interactive dynamic applets
- Learning theory on my own (outside classroom)
- Making exercises on my own (outside classroom)
- Checking model solutions for homework

The most important ways of learning was very teacher centered as the top one was “Making exercises during classroom sessions” and followed by “Personal guidance of lecturer during classroom sessions” and “Teaching with whiteboard / Using on-line instructional resources”.

It appears that in a point of view of the students modern ways of teaching math bases on utilizing technology.



were:

1. Using the modern technology in mathematic's learning purposes, increases my motivation towards courses concerned
2. The modern technology should be utilized more in university mathematic's teaching and learning.
3. I hope there would be more alternative learning and teaching methods in university mathematic's studying.

4. I hope that there would be more online content in university mathematics courses.
5. I hope that would be more online mathematic's courses in university.

Most important methods in terms of learning were very teacher centered whereas working alone outside the classroom was seen not important.

This is the problem we are facing in today's teaching – the contact lessons have been decreased.

CONCLUSION

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).

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