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THE USAGE OF MOBILE DEVICES IN THE STUDENTS' MATHEMATICS LEARNING

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Abstract. Mobile devices enables university students to develop innovative learning methods. The question is that can they exploit these potentials, do they know the relevant online curriculums, platforms and applications and do they have incentive for integrating mobile devices in their math learning process? In our survey, we searched the answers for these above issues. Our pilot survey suggests that the theme is very actual, arouses interest and we have to pay particular attention to the future research.

Keywords: math learning, mobile device, augmented reality, math application

Mathematics Subject Classification: Primary 97C30, 97C70, 97D40; Secondary 97U50, 97U70

1 Introduction

Nowadays, the Neumann Galaxy lives together with the Gutenberg Galaxy. Both printed books and mobile devices are applied. The question often arises: In which proportion should they be used by teachers and by students? We believe in the learner-centred pedagogy and we analyse this question from the student side. We are focusing on the types of mobile learning and talking about the change of mathematics learning.

In our research, we were interested in the quality of using mobile devices by students. The main questions in the questionnaire were: What do they generally use the smart tools for? What do they use the mobile technology for during their learning process? And in a new section we asked them about math learning with the help of mobile devices which the main topic of our survey was.

The balance between mobile learning and learning activities designed by a teacher should be found. The students of Neumann Galaxy are in a difficult situation if we think of the information flood but on the other side, they can reach easily that kind of information which

was unimaginable and inaccessible earlier. We are convinced that pedagogy changes irreversibly. The term "students" refers to university level students in all cases.

2 Theoretical background

"If we want students to become smarter than a smartphone, we need to think harder about the pedagogies we are using to teach them. Technology can amplify great teaching but great technology cannot replace poor teaching" (OECD, 2015, p. 4).

Today's students' needs were identified in six areas. These are the followings: Sharism, Shifting identities, Border-crossing, Literacies beyond print, A culture of gaming and A culture of bricoleurs. In details, you don't need to hide information. You do not have to be in a single role. You do not have to stay in one place. You do not have to learn the tools, it is enough to use them. There is no need to be motivated, only to give room for learning. There is no need for a rigid curriculum, but rather a tangible experience [1].

Mathematics is usually hated because it is difficult and incomprehensible. But if the education changes to the right direction and mobile devices get a little gamification in the math learning, this subject will become likeable.

It usually happens that both teachers and parents console their students by saying to them not to worry about doing badly in math because not everyone can excel in it. This resulted the appearance of the sentence: 'I'm not a math person'. Although the sentence is still alive in these days, the new evidence of brain research tells the opposite. Everyone, with the right teaching and messages, can be successful in math. According to researchers, there are a few children who have very particular educational needs, but the vast majority of them – about 95% - any levels of school math are within their reach [5].

During mathematics courses, student can make use of digital technology in various ways:

- during numerical calculations so they can concentrate on the solution of the problem itself;
- for visualisation, modelling and simulation of problems and thus to obtain such a graphical representation of the problem which pushes them towards a solution;
- as a source of educational materials e.g. e-books or videos, interactive educational materials;
- drilling exercises, a student can make use of electronic working sheets or e-tests to evaluate himself.
- They can use applications, such as: Geogebra, GeoMatech, 3D Geometry, Wolfram Alpha, PhotoMath etc.
- Watching videos about problem solving [15]

Moreover, the Augmented Reality technology enables us to develop new learning methods for mathematics learning. We are talking about augmented reality when with the aid of an application on a mobile device virtual objects can be displayed in the space we can see in front of us. Thus, we create a bridge between reality and virtual reality with the help of which we can reach great influence on every generation and achieve extraordinary results.

The term Augmented Reality (AR) was created by Tom Caudell, in 1990, while he was working at Boing, and it translates the integration of virtual images in the real world, i.e. the reality is augmented of virtual elements. The integration of such images is made by the use of Information and Communication Technologies (ICT), through a mobile device with a camera (computer, tablet, mobile phone with android or iOS operating systems) which allows the access to the available contents with AR. Furthermore, the development of such contents encourages higher learning autonomy and the use of systems that support mobile-learning. Besides, the exploration of ICT by the students can promote collaboration, innovation and creativity skills. One characteristic that AR applications offer is the integration and interaction between the real and the virtual, allowing a huge versatility and creativity in applications [8].

With students it is extremely motivating, if we make fields, which are difficult to understand, such as geometry, more comprehensible for students with the aid of augmented reality.
The main goal of geometry learning is to improve the spatial abilities. Spatial skills present an important component of human intelligence. The term spatial abilities contain five components, spatial perception, spatial visualization, mental rotations, spatial relations and spatial orientation. These abilities can be improved by virtual and augmented reality [12].

Our earlier research [16] carried out with the Augmented Polyhedrons application deals with the introduction of an application into primary schools, which portrays polyhedra in 3D. In mathematics and geometry education at high school as well as university level the Construct3D is a development which allows us to observe the changes in various geometric bodies that we have drawn and their connections with each other, e.g. sections, all in a manually controlled virtual space on a display placed on the head.

We think that these alternatives will be fully utilised one day by students. Teachers will be only the mentor on students learning process.
Mike Sharples [20] has made a good summary on different views of defining mobile learning. Current perspectives on mobile learning generally fall into the following four broad categories:

- *Technocentric.* This perspective dominates the literature. Here mobile learning is viewed as learning using a mobile device, such as a PDA, mobile phone, iPod, PlayStation Portable etc.
- *Relationship to e-learning.* This perspective characterises mobile learning as an extension of e- learning. These definitions are often are all-inclusive and do not help in characterising the unique nature of mobile learning. What is needed is clarity: in agreement with Traxler [21], the technocentric/e-learning based definitions only seek to place "mobile learning somewhere on e-learning's spectrum of portability".
- *Augmenting formal education.* In the mobile learning literature, formal education is often characterised as face-to-face teaching, or more specifically, as a stereotypical lecture. However, it is not at all clear that this perspective is wholly correct. Forms of distance education (for example, distance correspondence) have existed for over 100 years, leading to the questions regarding the place of mobile learning in relation to all forms of "traditional" learning, not only the classroom.
- *Learner-centred.* Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies".

Nowadays, there are vast online math learning possibilities. In this chapter, we present some platforms and math applications which can be used for teaching and learning. These tools are used by a significant part of the respondents of the questionnaire.

Separated in two categories, in the first part, you can read about searching platforms such as GeogGebra Materials, GeoGebraBook, GEOMATECH project and Planeta Vedomosti project as well. In the second part, several of the students' favorite applications are presented.

2.1 Sites with searchable online math materials

1. GeoGebra is an open source and worldwide used dynamic mathematics software. It covers all levels of math learning in primary and secondary school. We can use it for learning geometry and algebra, for spreadsheets, graphing, statistic and calculus. It is the master software in learner and learning centered pedagogy in the territory of STEM (Science, Technology, Engineering, and Mathematics). The software can be used for desktop but there are applications for tablets, which runs with Windows, Android and iOS and for mobile phones as well.
GeoGebra Materials (https://www.geogebra.org/materials/) is the platform where the GeoGebra applets can be saved to. This is the official cloud service and repository of GeoGebra lessons. There are more than 1 million searchable materials. Teachers can prepare *GeoGebraBook* for their students. These materials can be viewed and used on mobile devices as well.

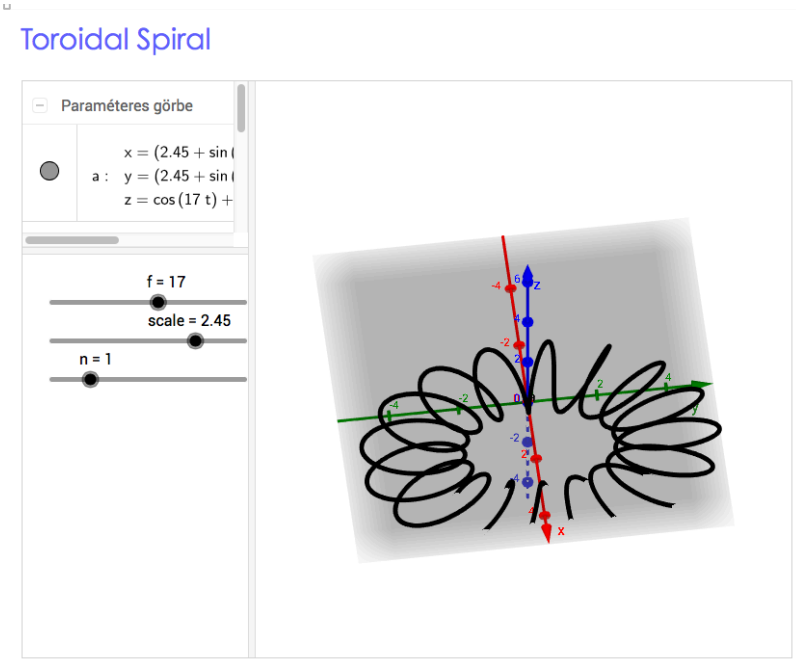

Fig. 1. Toroidal Spiral in GeoGebra https://www.geogebra.org/m/jy8mAzRk.

2. GEOMATECH (http://geomatech.hu) is a highlighted project in the Hungarian public education the goal of which is to have students like math and the other science subjects. This

is an online and interactive curriculum website, which can be used as digital math textbook too.
The curriculum portal is based on the GeoGebra software, which provides the potential for making interactive learning material. We can say that GEOMATECH is more than GeoGebra because it gives a frame to GeoGebra applet. Every exercise contains both the description of the problem and of the usage of GeoGebra applet.
We can easily search among subjects by choosing the class and the material, which we want to see.

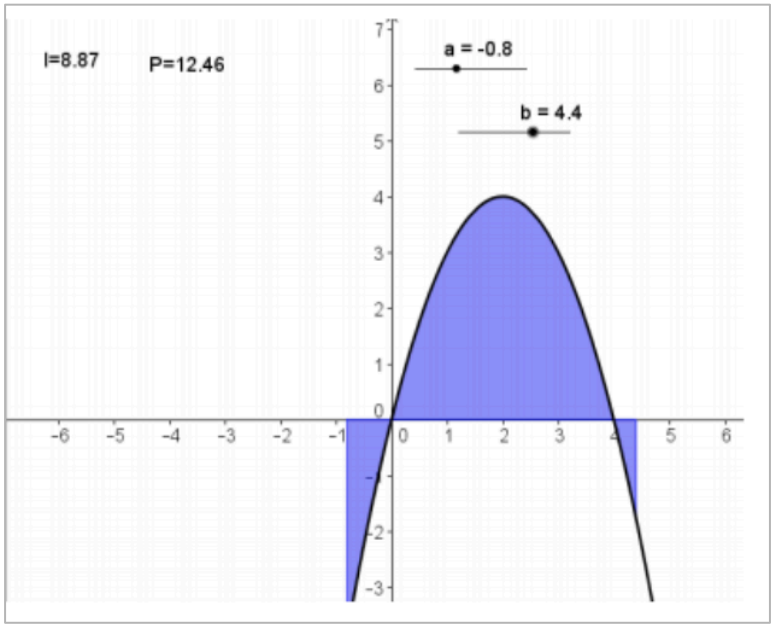

Fig. 2. Visualization of fractional calculus (Korenova, Takaci, 2014).

3. Planeta Vedomosti (http://planetavedomosti.iedu.sk) is a Slovakian, free of charge website. It contains a number of professionally made material for mathematics like videos, electronic worksheets and tests which are grouped together according to the curriculum topics for students and teachers alike. The content of this site covers a large part of both elementary and secondary school mathematics but also includes some topics for university students. It is accessible on computers and interactive boards but unfortunately only a part of these is available on smartphones.
Digital Library is the repository with lots of electronic materials and their methodological descriptions. They are categorized by the types of school, subjects and their use of ICT: https://www.modernizaciavzdelavania.sk/Digi/DigiLibrary.aspx

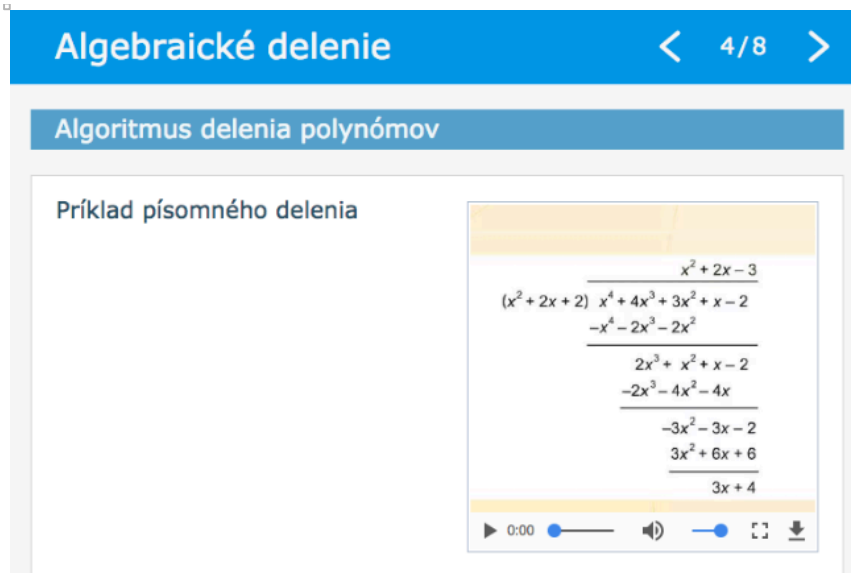

Fig. 3. Planeta Vedomosti - http://planetavedomosti.iedu.sk

2.2 Mathematics applications

1. *GeoGebra* has now four apps for iOS and seven apps for Android. We present the most often used ones of them.
GeoGebra Graphing Calculator easy to utilize for graph functions, solve equations, find special points of functions.
GeoGebra Geometry easily construct triangles, drag points, draw parallel lines, and intersect circles.
GeoGebra Classic is applicable for solving math problems, graph functions, create geometric constructions, do statistics and calculus.
A first version of *GeoGebra Augmented Reality* app was launched this year (2017) only for iOS platforms, but this is under construction. With this app, the developers would like to explore the potential of AR for learning and teaching mathematics.
2. *Wolfram Alpha* is an education tool, which can give answer for almost everything which is needed in the secondary school. This is a tool, which calculates the math problems and answers the questions. These possibilities are free of charge but there are some potential which you can get only in paid Pro version. For instance, if you want to upload a photo with math problem the solution of this is only possible in version Pro.
Wolfram Alpha has apps for iPad, iPhone, Android, Windows Phone and Tablet and Kindle fire.
3. *Photo Math* is a free 2D AR app for Android and iOS. We point our camera toward a math problem and Photomath will show the result with a detailed step-by-step instruction. What is really exciting about it is that this app contains handwriting recognition. We tried it and the result was excellent. PhotoMath, also named camera calculator, makes math problems easy to solve and everyone is motivated to continue this “game”.

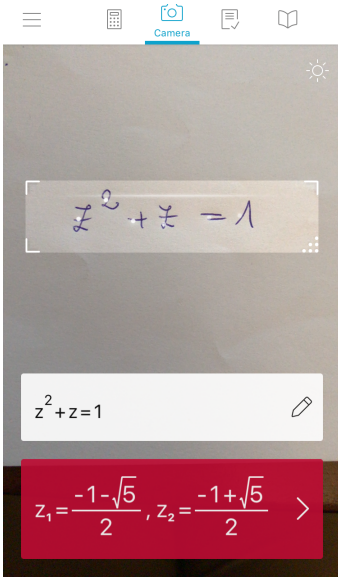

Fig. 4. Resolution of a handwritten equation ($z^2+z=1$).

There are many other applications in this segment of education but we just focused on the well-known and used ones.

3 M-learning in our region

We studied the M-learning current situation in Slovak, Hungarian and Romanian universities. At the present, nearly all schools make use of some kind of digital technologies in education. Digitaliada (http://digitaliada.ro) has been a special program for rural areas digital math education in Romania since 2016. The project covers 30 secondary schools from the countryside, this means 3400 students and 82 teachers. The site of Digitaliada is a platform for collecting new online materials in this theme as well.

The most active Hungarian blog is TanárBlog (http://tanarblog.hu) made by Prievara Tibor and Nádori Gergely. This blog is an almost daily updated site with actual and exciting content about the Hungarian digital education. Essentially it is a teacher blog as its name shows, where the authors share their teaching experience in M-learning too, but unfortunately only in Hungarian. Prievara has also created a new electronic evaluation system which is used by other teachers. The ICT Association in Hungary (http://ivsz.hu/en/) is concentrating on the education and digital skills in schools with Program for promoting digital education and The Digital Thematic Week.

There are many projects, domestic and foreign, which are focusing on pilot introduction of M-learning to schools. In Slovakia, there are currently two such projects that can be found under the following links: http://www.skolanadotyk.sk and http://www.digiskola.sk. The former project, “school by touch”, was an initiative from private companies, which supplied ten schools with interactive whiteboards and tablets for every pupil in a classroom. Besides equipping schools with technology, teacher trainings were carried out as well and an empirical research was trying to determine the effectiveness of teaching using these technologies. Teachers were creating demonstrational materials suitable for M-learning, students created and shared videos. They are available at

http://www.skolanadotyk.sk/materialy.html. At a conference that followed the project's end, the research team stated that in all subjects except mathematics, significant results were gathered which point out the effectiveness of such education. We presume that the case of mathematics classes was caused by insufficiently digitally literate teachers of mathematics. The latter project started in 2014. The Ministry of Education of the Slovak Republic, using EU funds, bought 5680 interactive whiteboards, 5680 notebooks, 2686 colour printers, 20000 tablets and 1000 Wi-Fi routers for schools all around Slovakia.

4 Research design

The usage of mobile devices in the students' mathematics learning research is based on an online questionnaire which were made, spread and analysed by the authors.

The purpose of this survey is to compare the characteristics of the use and adoption of mobile learning in higher education in three countries. These are Slovakia, Hungary and Romania. The main scope of this study is to survey the utilization of the mobile devices in the students' math learning and their opinion about the usage of mobile technologies in the learning process.

Research questions: In which proportion do university students use mobile devices in their learning process, especially in mobile math learning and what is their opinion about the utilisation of these devices in learning?

4.1 Survey

In order to get answers for our questions, we chose an online survey based on questionnaires.
There were two questionnaires, one in Hungarian language and another in Slovakian language. Both the Slovak and Hungarian questionnaires were launched in Slovakia. The Hungarian language questionnaire was sent to almost all the universities in Hungary and Transylvania. Unfortunately, we caught only the Hungarian minority in Romania because we don't have enough connection with the Romanian colleagues.
The questionnaire needs only few minutes (approximately 5 minutes) to be filled. There are three sections, demographic and geographic characteristics, mobile devices in students learning and especially in math learning and finally it contains questions about their opinion in this theme.

Some of the most essential research questions

1. Are students utilising smartphones, tablets, e-Book Readers and other technologies in their learning? If yes, for what? Is there a difference between Slovakian, Hungarian and Romanian students regarding the utilisation of these technologies?
2. What technologies do Slovakian, Hungarian and Romanian students prefer for study purposes?
3. Are students utilising mobile devices for math learning? Which math applications do they know and which ones do they utilise?
4. Are their teachers encouraging the use of smart tools in the classroom?
5. What are the students' opinion about M-learning, about the mobile devices in math learning and about the degree of which their professors are using these tools?

6. What challenges are associated with mobile math learning in these three countries?

The filling period of the research called 'The usage of mobile devices in the students' mathematics learning' was between 27.11.2017. and 10.12.2017. On the first day, we sent a lot of emails to our teacher and researcher colleagues to Slovakia, Hungary and Romania. Altogether the questionnaires were sent for more than 50 colleagues in Hungary and 30 teachers both in Slovakia and Romania.
In the second round, we posted the questionnaire on the universities' students Facebook groups.
Almost all of our colleagues were very cooperative and the answers come one after the other. They said that they had sent it for their students or for the student council. There were a few cases when it was sent for the whole university on Neptun platform. Some students spread it on their own network.

The target group of the survey is the university students of the three countries studying in full time or distance learning, both from science and art territories.

There are 525 responses total, 391 responses arrived from the Hungarian language questionnaire and 134 from the Slovakian language one. The distribution of them by gender, kind of training and countries can be seen in the table below.

		Total responses by gender		Total responses by the type of learning process	
Country	Total responses	Male	Female	Full-time training	Distance learning
Hungary	187	88	99	104	81
Slovakia	141	20	121	90	36
Romania	194	92	102	128	65

Tab. 1. The distribution of responses.

These students were born into the digital world, and independently from their age and learning language and the kind of faculty where they are studying, they almost have smart tools in their pockets for sure. 98.2% of the respondents possess mobile devices. It is interesting that the over thirty year category gave the most active respondents and they are also the winner of the category containing respondents without mobile devices (Fig.5.).

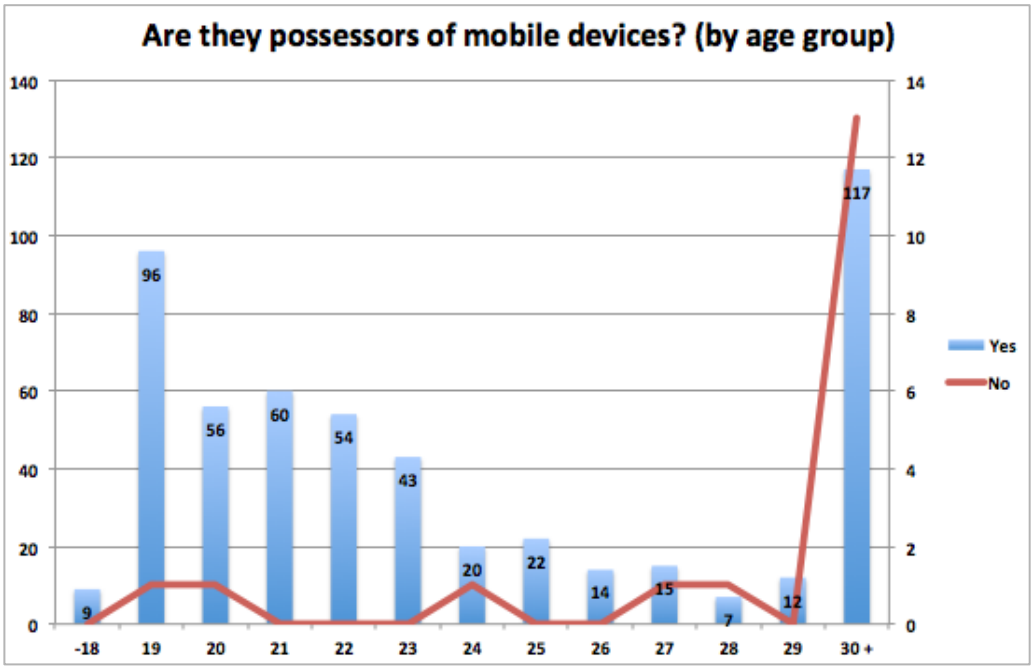

Fig. 5. Combination chart of age groups and their two categories to all respondents.

We were interested in seeing their habits in using mobile devices both in private life and at courses. As we thought, they use the mobile devices in their private life first of all for chatting, checking emails and social media platforms, making photographs and searching for information. The answers were similar in the three countries to this question, so we can say that there is not any difference between Slovakian, Hungarian and Romanian students regarding the utilisation of these technologies (Fig.6.).

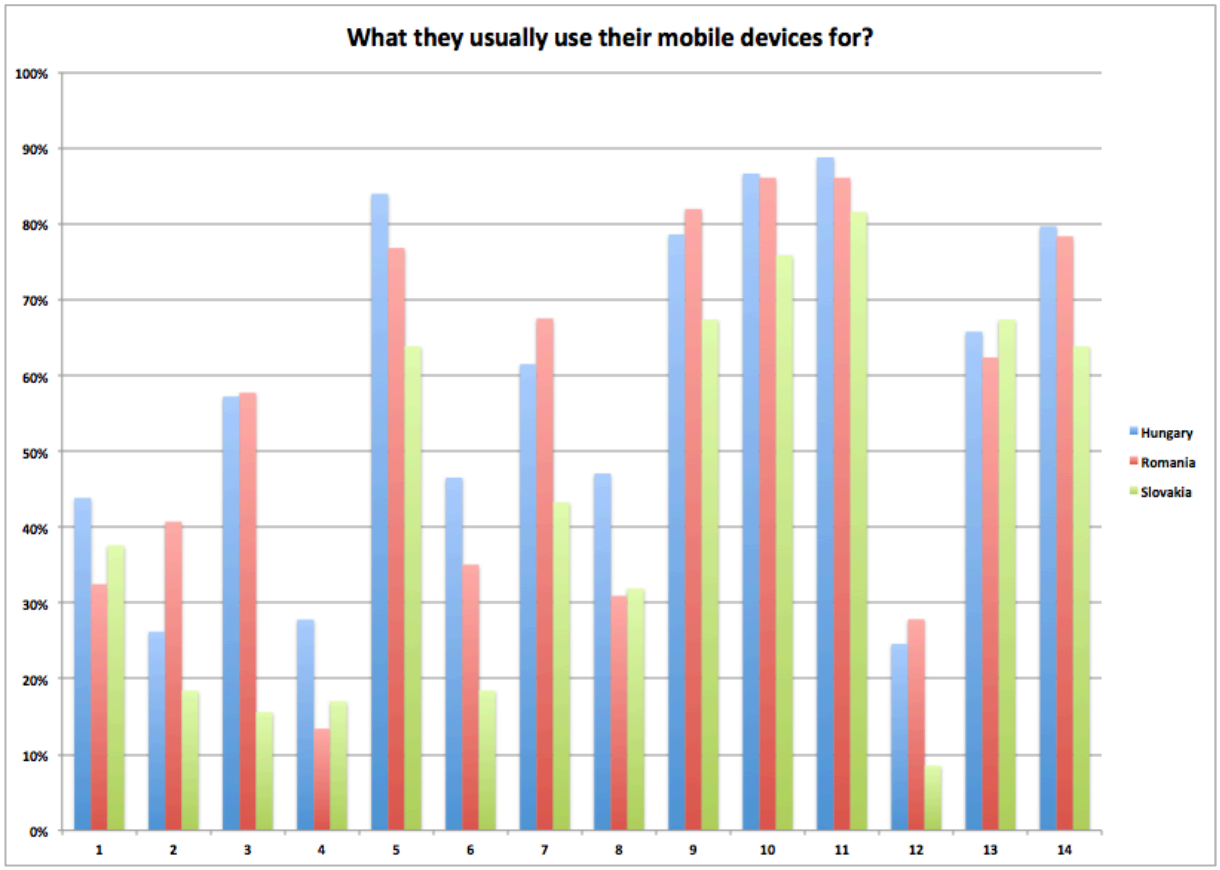

Fig. 6. The similar scores of using mobile devices in their private life.

1 - For online shopping, 2 - I use the Calculator, 3 - I use the online maps (e.g. Google Maps), 4 - For booking an appointment at different institution, 5 - For making photograph, 6 - I use the Cloud Systems (as Google Drive, OneDrive, Dropbox, iCloud), 7 - I use online dictionaries and translator programs as well (Google Translator, Glosbe, Dictzone), 8 - For mobile banking, SmartBanking, 9 - I use for checking my social media platforms (Facebook, Instagram, Twitter, SnapChat, Pinterest etc.), 10 - For chatting (Facebook Messenger, Viber, WhatsApp, Skype), 11 - Checking my emails, 12 - I use them during my sports training for checking my performance, 13 - I use the Calendar, 14 - For information searching

In the second section of the questionnaire, we asked them about the general usage of mobile technologies during their learning process. We can see that they rarely use them for solving math problems. (Fig. 7.).

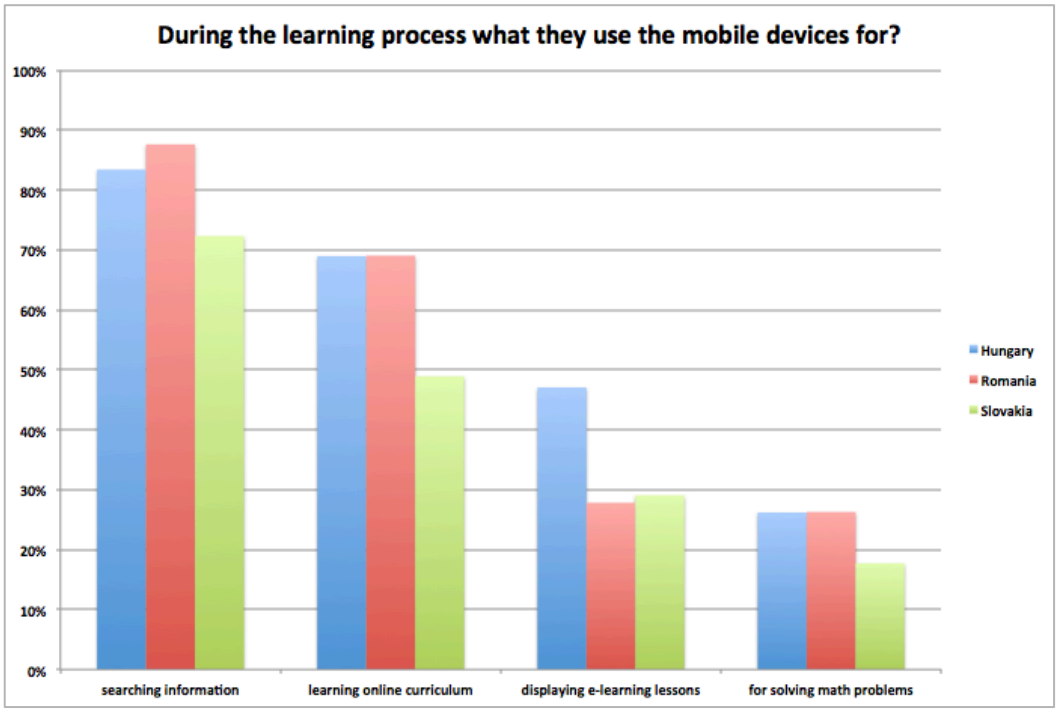

Fig. 7. Generally usage of mobile devices.

The main scope of the survey was to estimate the students' knowledge concerning math applications. This is a relatively new potential in education. Therefore we searched for the answer of the question which math applications they know and utilise. We can see above the top 7 applications used by students (Fig.8.).

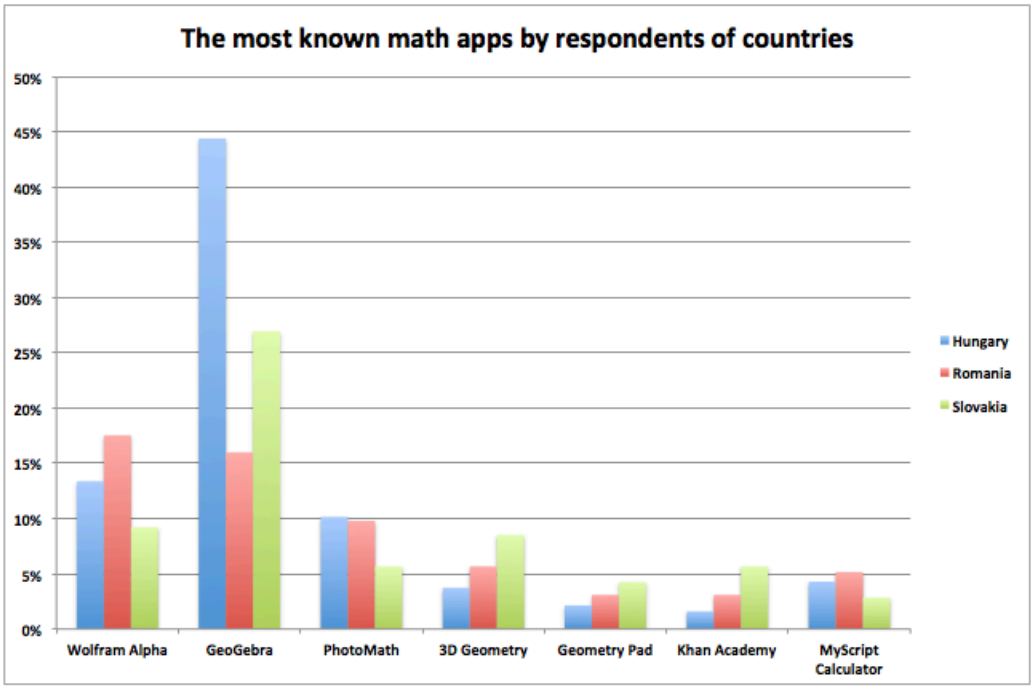

Fig. 8. Comparison of top 7 used application.

The quantitative research surpassed our waiting, because university students have other more interesting programs. We were satisfied with the number of the completed questionnaires. It can be said that Romanian students (who were in reality Transylvanian students) were the most active. We know that this generation was born into the digital world but that does not mean that they have highly developed digital competence. They are not native digital, but they are the children of Neumann Galaxy whose digital competence emerges only from their everyday usage. They are influenced very much by their cultural environment.

5 Conclusion

Today's students are always online, they live in the digital world. They can get the needed information it within a few seconds. At the same time, they have to learn the operation and the rules of the digital world because the information received is not a credible information in every case. They have to know some important searching rules, relevant sites, considerable applications, and they have to use the social media platforms intelligently if applicable.

In this article we searched the answer for the question that in which proportion do university students use mobile devices in their learning process, especially in mobile math learning and what is their opinion about the utilisation of these devices in learning?
For this purpose we establish a few lists about the university students' activities on their mobile devices. One list is about the possible online daily activities, the other is about online practices belong to learning and finally about math applications used by them. These lists were put in questionnaires made in Slovakian and Hungarian language and spread both in Hungary and Slovakia and in the Transylvanian part of Romania.
We obtained several interesting results. To the question that do their professors encourage the usage of mobile devices 40% of the respondents said yes. It is also interesting that the over thirty-year category gave the most active respondents and they are also the winner of the category containing respondents without mobile devices.
In our opinion, students do not know enough about the potential of mobile devices in learning. The solution is in the hand of the teachers. They can inspire students by changing the teaching method and allowing them to utilise mobile devices in their learning process. Additionally, it would be better if universities supported the development of more curriculums which can be used on these devices as well.
Our pilot project highlights this essential theme which naturally needs further survey. One possible future research can be about the influence of apps on the students' math learning.

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