Mobile learning in elementary and secondary school mathematics in Slovakia

Lilla Korenova
lillakorenova@gmail.com
Comenius University in Bratislava
Bratislava, Slovakia, SK

Abstract

Nowadays, using mobile technologies for younger generations is becoming an everyday reality. Smartphones and tablets combined with mobile Internet are easily accessible to students and are a part of their everyday life. Mobile learning is a type of education which uses mobile technologies, like the smartphone, tablet or PDA with access to the internet. In this paper we acquaint with the current situation of using mobile learning on secondary and elementary schools in Slovakia. We also present a few examples of different methods and forms of teaching mathematics in elementary and secondary schools using mobile technologies.

1. Introduction

We live our everyday lives in an environment, where we cannot imagine a day without a computer, the Internet, a cell phone and other ICT products. Elementary and secondary school pupils were born into this world and it's natural to them. Fortunately, this natural environment is already reaching into schools. By the term "digital environment in schools", we mean digital technologies that can be used for teaching. In this set of tools belong not only the computers and notebooks, but smartphones and tablets as well, which can be equipped with appropriate software and be used for electronic education (e-learning). The term "e-learning" can be understood two ways. Mostly by e-learning, we mean electronic form of distance learning. However, in a wider meaning, e-learning stands for any kinds of education done via electronic devices. In the past few years, we witnessed mobile technology entering school environments too.

According to the European Commission/ICT cluster, 2010 there exists an increasing discrepancy between the possibilities of using ICT at home and in school, therefore schools should support the development of modern technical environment, thus connecting their experience with these devices at home with school and prepare them for real life situations. [1]

Mobile learning is a type of education which uses mobile technologies, like the smartphone, tablet or PDA with access to the internet. For the teacher new teaching possibilities open up while using mobile learning or blended learning. Through these methods they are "granted access" to different interactive and multimedia study materials on the internet.

Digital technology offer teachers a possibility to make use of new educational methods, e.g. the constructivist approach, controlled search, workshop method or peer instruction method. Digital technologies are very suitable for project teaching, too. Teachers can make use of blended learning, flipped classroom method, etc. Last but not least, the computers are used for electronic testing when knowledge of the pupils is measured.

During mathematics classes, pupils 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 pupil can make use of electronic working sheets or e-tests to evaluate himself.

From a didactic point of view, we can use these resources in different teaching methods:

- method of controlled discovering,
- project education (this is another rising form of mathematics teaching, which is gaining new possibilities in the digital environment. Students use mostly cooperative learning, which is enabled by m-learning),
- peer instruction method (in this case, the tablet is used as a voting device),
- "The flipped classroom" method, etc.

From an educational point of view, teaching with a tablet is appropriate for both individual and collective work.

According to Peter Lukáč, the use of a computer while teaching can contribute to fulfilling some didactic functions:

- motivation - the computer can contribute to forming positive attitude towards leaning
- informative function
- driving function - highly interactive educational programs can control the exchange of opinions between the subject of education and the computer
- rationalization function - proper integration of the computer into the educational process can support the differentiation of procedures and methods of teaching regarding the relations towards individual students
- control function - using the computer can make diagnosis and evaluation of educational results much more effective
- communication function - computer aided teaching supports mutual communication between students
- social function – work in groups. [2]

2. Theoretical framework

The technological and social changes that accompany the current ubiquitous use of mobile devices are also reflected by the widely accepted notion that learning is continual and happens anywhere at any time [3]. Unfortunately, however, this stands in sharp contrast to the prevalent learning situation in schools, which is still almost exclusively focused on classroom-bound learning, mediated by a trained teacher. [4]

Carefully designed and custom-tailored mobile classroom learning applications have been found valuable to bridge the gap between indoor and outdoor learning.

In particular, mobile learning applications serve as assistive didactic tools that contextualize learning contents previously introduced in the classroom. This is achieved by exemplifying and augmenting the students' formal classroom learning experiences in outdoor scenarios, thus enabling the students to actively and dynamically construct an understanding of their activities. [4]

Successfully bridging indoor and outdoor classroom learning is a complex task, which includes the use of technology in an individual, social, and organizational context. These factors comprise the heterogeneity of the people involved (i.e., teachers, students, and researchers, as well as their different motivation, knowledge, etc.), the specific learning goals or sub-goals, the methodology and devices used, economic factors, and the interrelations and dynamics between these factors. [5]

We can find several approaches to defining mobile learning in professional literature:

Mobile learning refers to the use of mobile or wireless devices for the purpose of learning while on the move. Typical examples of the devices used for mobile learning include cell phones, smartphones, palmtops, and handheld computers; tablet PCs, laptops, and personal media players can also fall within this scope. [6]

Peters viewed mobile learning as a useful component of the flexible learning model. In 2003, Brown summarized several definitions and terms and identified mobile learning as "an extension of e-learning". [7]

Taylor [8] has defined mobile learning as "learning mediated by mobile devices, or mobility of learners (regardless of their devices), or mobility of content/resources in the sense that it can be accessed from anywhere". [8] One-to-one learning with a mobile device falls into the same category of mobile learning in which learners use a mobile device (e.g., iPads, iPods, netbooks, laptops, cell phones, or other mobile devices) with Internet access to engage in learning activities. Many school districts may restrict the access to classroom use for fear of damage, lost, or misuse. [9]

Mike Sharples [11] 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 [9], 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". [12]

3. M-learning - the current situation on Slovak schools

At the present, nearly all schools make use of digital technologies in education. Most schools are equipped with computers, interactive whiteboards (often many) and teachers have access to notebooks with projectors. However, few schools have interactive whiteboards in every classroom, there they cannot use it all the time. Most of the students own a smartphone and still more of them own a tablet. Despite this fact, education that incorporates mobile learning is spreading slowly.

There are many projects, domestic and foreign, which are focusing on pilot introduction to m-learning to schools. In Slovakia, there are currently 2 such projects that can be found at 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 10 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 trying to determine the effectiveness of teaching using these technologies. Teachers were creating demonstrational materials suitable for m-learning, students created and shared videos from classes. They are available at http://www.skolanadotyk.sk/materialy.html . On a conference that followed the project's end, the research team stated that in all subjects except mathematics, significant results were gathered that point out the effectiveness of such education. We presume, 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 color printers, 20000 tablets and 1000

wifi routers for schools all around Slovakia. At the moment, teacher training is under way regarding the use of tablets. In the next phase, the ministry wants to create digital content as well. Besides these projects, there exist several individual initiatives by mathematics teachers, which experiment with tablets and smartphones for teaching mathematics during classes.

At the moment, teachers of mathematics in Slovakia use tablets and smartphones in several ways:

- Pupils are solving e-tests, electronic worksheets for exercising
- Giving access to electronic study materials
- Solving activities, which could not have been utilized without the functions of mobile devices (project teaching, constructivist teaching using a camera, GPS, etc.)
- Smartphone as a voting device
- Using some applications for mobile devices

Some of the above mentioned activities can be done on a PC as well, but for teachers as well as for students it's easier to use a tablet or a smartphone, than to move to a PC classroom.
In the next part, we present a few examples:

Tablets - alternative for eBook readers.
This means they can be used for studying from school books in electronic forms. Some mathematics school books are available in electronic form in Slovakia.
The portal eAktovka (http://.www.eaktovka.sk/) gives access to digital school books for students in elementary and secondary schools. These are available for free for all that register on this website. Among else, students can also access other internet sources in text, image, audio or video form.
Many mathematics teachers use the portal http://www.zborovna.sk . It's a web portal, created for exchanging information among teachers, parents and students. It's available for a small fee, which is covered by the school for every of its teachers and students. The portal is very popular and it is being used mostly for sharing PowerPoint presentations regarding a given topic. For this reason, we can classify this portal as a source for multimedial and explanatory materials suitable for m-learning as well. The disadvantage is, that these materials do not undergo a reviewing process and small context errors occur or in the method of explanation.

E-tests on tablets
In this part, by "e-test", we mean that e-test is an electronic, interactive material based on a system of questions and the search for answers, created not only for evaluation, but also for achieving educational goals (therefore it can server as an aid for innovative teaching methods).
E-tests can not only be used in classrooms equipped with computers and laptops but they are getting more commonly used on tablets too. One of the most popular e-test making software among teachers in Slovakia, which is available for free, is HotPotatoes. Website: http://hotpot.uvic.ca/index.php. Multiple choice tests, crosswords and other methods are great for reviewing study materials, using interactive whiteboards, notebooks, tablets or smartphones.
Tablets and smartphones can serve as voting devices (instead of clickers). For this purpose, teachers mostly use the software SmartNotebook14, electronic tests in LMS Moodle or Google Docs Sheets. During mathematics classes, we can use tablets for e-tests not just to measure the students' knowledge, but also for exercising the study materials with immediate feedback. The advantage of this is, that every student can progress with their own pace and gets immediate feedback. In more carefully prepared e-tests, the student can get help, or view some pre-solved examples. In such organized class, the teachers can focus on less advantaged students. From a methodical point of view, teachers use HotPotatoes mainly for creating study materials in modern and attractive forms.

Currently, there are many portals and recently even applications for smartphones, which were designed for digital education of mathematics via m-learning:

- website of PaedDr. Katarina Polacikova http://www.supermatematika.wbl.sk
- website of RNDr. Martha Megyesi http://megym.wbl.sk
- tests on the website of the University in Trnava http://vcv.truni.sk/tests.php .

Figure 3 is an example of an e-test, created during mathematics classes as an electronic worksheet

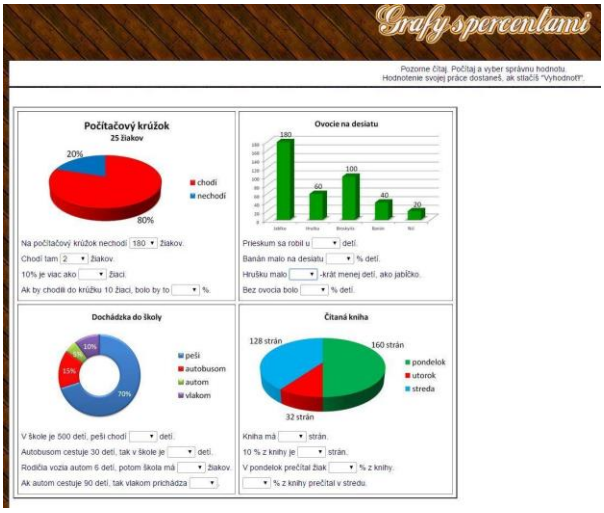

Figure 1: example of an e-test http://megym.wbl.sk/percenta_grafy.htm

Some of the applications that are being used during mathematics classes on some schools in Slovakia:

Within the project "DIGISKOLA", the following applications are recommended for smartphones and tablets:

- GeoGebra app https://play.google.com/store/apps/details?id=org.geogebra

suitable for elementary and secondary school mathematics.

Some applications server as a substitute for graphical calculators:

- Graphing calculator app https://play.google.com/store/apps/details?id=com.herbertlaw
- Graphing calculator Mathlab https://play.google.com/store/apps/details?id=us.mathlab.android
- Fraction Calculator by Mathlab https://play.google.com/store/apps/details?id=us.mathlab.android.frac
- WolframAlpha https://play.google.com/store/apps/details?id=com.wolfram.android.alpha

Furthermore, these applications contain formulas and instructions:

- Pocket geometry https://play.google.com/store/apps/details?id=sk.halmi.geometryad
- Math formulary https://play.google.com/store/apps/details?id=com.anjokes.apps.math.en

The last category are brain teasers/logical puzzles:

- Logical https://play.google.com/store/apps/details?id=com.chilled.brainteasers

There are applications as well, that allow teachers create their own e-tests, such as:

- Socrative https://play.google.com/store/apps/details?id=com.socrative.teacher

Examples of using the GeoGebra software in tablet or smartphone

Tablets with internet, camera, software such as GeoGebra (website: http://www.geogebra.org) and other applications are practically designed for constructivist methods during mathematics classes. This kind of work is very motivating for students. On the other hand, it requires very consistent preparation.

Example: Ellipse

In Slovakia, according to the current, valid educational standards, educational material about the ellipse is no longer mandatory in secondary school mathematics. In geometry however, the material 'A set of points with a given property' is still taught. Using GeoGebra, we can enable the students to discover the construction of an ellipse as a set of points with a given property.
In the next example, we are demonstrating how to use the software GeoGebra on tablets using the controlled research method.

Activity 1: is a combination of manipulation and construction. Students use 2 pins and a cord to draw a curve by stretching the cord. Questions of the teacher are heading to a discovery, that they are creating a curve: a set of points, where the sum of distances between the pencil's head and pins is constant and equal to the cords length. They capture this experiment with a tablet (Figure 2).

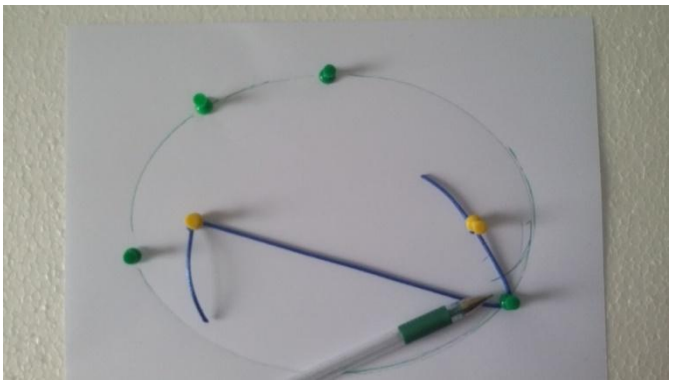

Figure 2

Activity 2: Students replicate the former work in GeoGebra. They transform a real-life situation into a mathematical model. Teacher is leading the students towards precise geometric formulations.
Solution: See the file ellipse01.ggb at the section 7. (Figure 2)

Activity 3: Students paste the photography of their experiment as a wallpaper for their GeoGebra file and move points F_1 and F_2 and the line segment, therefore modelling the creation of the curve.
Solution: See the file ellipse02.ggb at the section 7. (Figure 3)

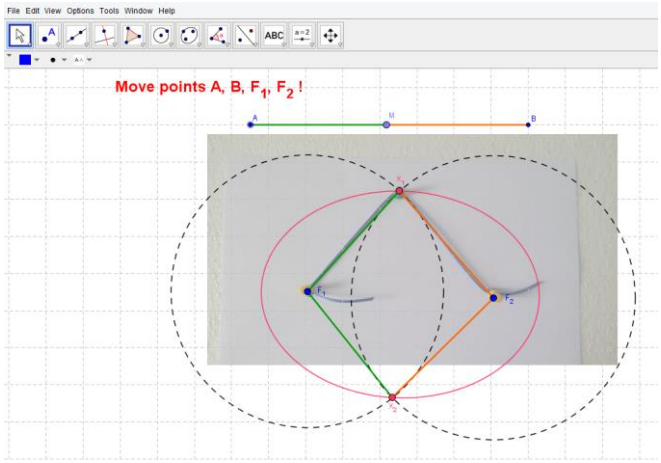

Figure 3

The teacher can use any different method for discovering the ellipse, other than a set of points with a given property. Solution: See the file ellipse03.ggb at the section 7. (Figure 4).

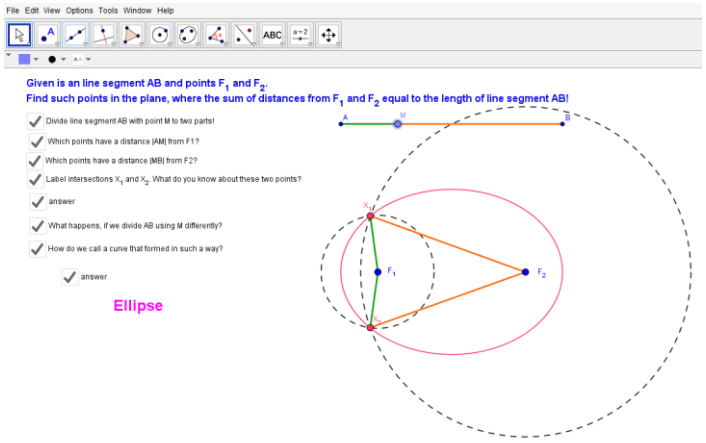

Figure 4

Some pupils can experiment further on in space. What will be the set of points, where the sum of distances of points to F and G remains constant, if you consider 3-dimensional space? There is already a 3D version of GeoGebra on tablets. Solution: See the file ellipse3D.ggb at the section 7. (Figure 5).

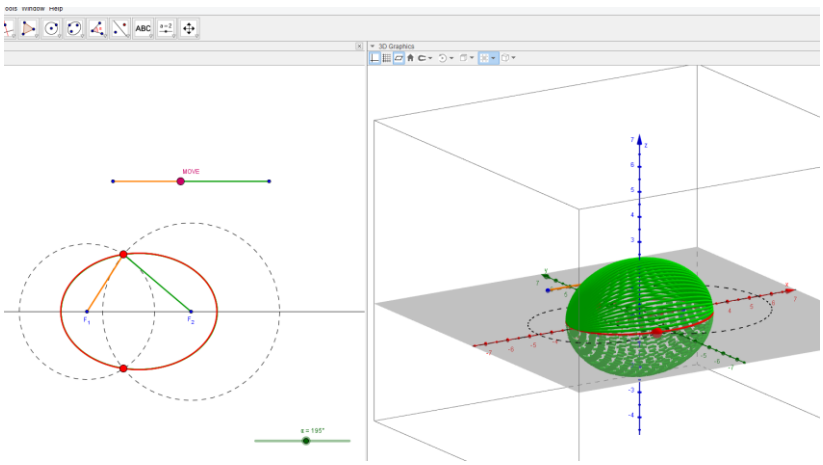

Figure 5

4. Survey

In May and August this year, a survey, using an electronic questionnaire, was carried out. The aim of the survey was to identify the state of affairs in schools – how they are equipped with digital technologies (laying focus on blended learning, and m-learning) and their use in mathematics teaching.

We addressed more than 500 teachers of mathematics (via email), that all participated in teacher trainings on our University or in the past cooperated with our University. Furthermore, we addressed teachers of mathematics on Facebook in https://www.facebook.com/groups/uciteliamatematiky/ - this group has more than 500 teachers from Slovakia. 94 mathematics teachers from the entire Slovakia completed the questionnaire.

The teachers were 26 – 60 years old, their average age was 44; 87 % of them were women, 37 % were men. 74 % of the teachers indicated that informatics is not their second qualification, so we can therefore presume that the results were not distorted in this respect either. 47 % of them were teachers at primary schools, 48 % teachers at secondary schools and the remaining 5 % of them were teachers at special schools, so the distribution of respondents was even.

In the first part of the questionnaire we tried to find out what the school equipment was and how the teachers could use it for mathematics teaching. 43 % of the teachers indicated that their school had 2 PC labs, 15 % of the schools had 3 PC labs and only 10 % of the schools had more than 5 PC labs. These PC labs were used mostly for mathematics teaching. 48 % of the teachers indicated that they could use the PC lab for mathematics teaching whenever they wanted, 29 % of the teachers indicated that they had also mobile classrooms at their disposal - meaning notebooks for one class. 30 % of them could use them for mathematics teaching whenever they wanted.

As for Interactive Whiteboards (IWB), only 26 % of teachers indicated that their schools lacked IWBs, 40 % schools had one, 18 % two and the rest 3 and more interactive backboards. Only 2 % of schools had IWBs in every classroom. It turned out that the teachers had enough projectors at their disposal. There is a satisfactory number of projectors, fixed or mobile, in each school. The teachers had at their disposal document cameras at 8 % of schools and only 5 % of schools were equipped with a clicker for IWBs. Tablets were used at 36 % of schools; as for graphic calculators, 9 % of teachers indicated that they had them at their schools.

In the end of the questionnaire, we asked what teaching methods or forms teachers use during mathematics classes (when they take use of DT). So many as 64 % of the teachers used DT often for presentation, it means for a classical lecture, 27 % of the teachers indicated that they had used DT in a method of directed investigation (what is a constructivist approach), 45 % of the teachers had used this method from time to time. 63 % of the teachers used the project method with DT often or from time to time. 24 % of the teachers used electronic tests as HotPotatoes on various hardware (PC, NB, Tablet) for practising the subject matter very often, 33 % from time to time, 18 % seldom, and 23 % never. The teachers almost did not use the workshop method nor the flipped classroom.

We asked the teachers the following questions: “Do you think, that DT can enhance the attractiveness of mathematics teaching?” and “Do you think that DT can improve the level of mathematics knowledge?” and most of the teachers answered “yes”.

At the end of our survey, we can conclude, that despite the significant growth of technologies in Slovak schools, their use reaches a grade 2 on the scale by Marc Prensky: "Doing old things in old ways". [3] Teachers of mathematics feel the need to introduce new teaching methods with new technologies, however for various reasons, this is being done in chaotic ways.

5. Conclusions

The quick rise of DT and their entrance to the lives of students, brings forth many questions about their effective use. Experience shows, that pedagogic research in the field of theory of teaching mathematics must go this way. The use of mobile technologies in teaching mathematics proves itself to be very effective and is attractive and motivating for students. The use can be applied from elementary schools to Universities. At the same time, a strong need occurs for good quality e-materials and e-tests in mathematics for m-learning. According to our opinion, it’s of the best interest to use free and well-made software, such as GeoGebra, HotPotatoes and free applications from the Google Play store for the Android operating system. Even universities educating future teachers of mathematics should be addressing this problem more intensively. We believe, that by the use of innovative methods of teaching in a digital school, we can stop the decrease of popularity of mathematics on elementary and secondary schools.

6. Acknowledgements

This paper arose thanks to the support of the project KEGA 094UK-4/2013 „Ematik+, Continuing education of mathematics teachers“
http://elearn.ematik.fmph.uniba.sk

7. Supplementary Electronic Materials

[a] ellipse01.ggb
[b] ellipse02.ggb
[c] ellipse03.ggb
[d] ellipse3D.ggb

8. References

[1] ISFTIE, "ISTE Standards for Students resources," The International Society for Technology in Education, 2014.

[2] S. Lukáč, Multimédiá a počítačom podporované učenie sa v matematike, Košice: UPJŠ, 2001.

[3] M. Prensky, "Shaping Tech for the Classroom," 2005. [Online]. Available: http://www.edutopia.org/adopt-and-adapt-shaping-tech-for-classroom.

[4] Mishra, P., Koehler, M. J., & Kereluik, K., "The song remains the same: Looking back to the future of educational technology," *TechTrends,* vol. 53, no. 5, pp. 48-53, 2009.

[5] Mishra, P. & Koehler, M. J., "Technological Pedagogical Content Knowledge: A new framework for teacher knowledge," *Teachers College Record,* vol. 108, no. 6, p. Teachers College Record, 2006.

[6] Mishra, P. & Koehler, M. J., Introducing Technological Pedagogical Content Knowledge, Washington, DC: AACTE Committee on Innovation and Technology, 2008.

[7] Niess, M. L., Ronau, R. N., Shafer, K. G., Driskell, S. O., Harper S. R., Johnston, C., Browning, C., Özgün-Koca, S. A., & Kersaint, G., "Mathematics teacher TPACK standards and development model," *Contemporary Issues in Technology and Teacher Education [Online serial],* vol. 9, no. 1, 2009.

[8] Lukáč, Stanislav a kol., Využitie informačných a komunikačných technológií v predmete Matematika pre stredné školy, Košice: elfa s. r. o., 2010.

[9] L. Koreňová, "Usage possibilities of e-tests in a digital mathematical environment," *Usta ad Albim Bohemica,* vol. XIII, no. 3, pp. 77-83, 2013.

[10] J. Gunčaga, "GeoGebra in Mathematical Educational Motivation," *Annals. Computer Science Series,* pp. 75-84, 2011.

[11] Štrausová, I., Hašek, R., "Dynamic visual proofs using DGS," *The Electronic Journal of Mathematics and Technology,* vol. 7, no. 2, pp. 130-142, 2013.

[12] I. Kalaš, "Škola ako príležitosť," 22 2 2011. [Online]. Available: http://clanky.rvp.cz/clanek/c/z/10613/SKOLA-AKO-PRILEZITOST.html. [Accessed 2014].

[13] E. Partová, Vyučovanie matematiky pomocou moderných technológií, Bratislava: Univerzita Komenského v Bratislave, 2011.

[14] O. a. k. Šedivý, Vybrané kapitoly z didaktiky matematiky, Nitra: Univerzita Konštantína Filozova v Nitre, 2013.

[15] E. Velikova, "Geo-Gebra: Technology can advance creative mathematical activities in the classroom.," 2011. [Online]. Available: http://www.igmcg.org/files/newsletter_1.pdf.

[16] K. Žilková, Školská matematika v prostredí IKT, Bratislava: Univerzita Komenského Bratislava, 2009.

[17] J. P. Gee, "What video games have to teach us about learning and literacy," *Computers in Entertainment (CIE),* vol. 1, no. 1, p. 20, 2003.

[18] M. C. D. &. W. O. Sharples, “The design and implementation of a mobile learning resource,” *Personal and Ubiquitous Computing,* vol. 6, no. 3, pp. 220-234, 2002.

[19] Melzer, André, et al., “Using iterative design and development for mobile learning systems in school projects,” in *Proceedings of ICEC CELDA*, 2007.

[20] Y. Park, “A Pedagogical Framework for Mobile Learning: Categorizing Educational Applications of Mobile Technologies into Four Types,” *International Review of Research in Open and Distributed Learning* , vol. 12, no. 2, 2011.

[21] Melzer, André, et al., “Using iterative design and development for mobile learning systems in school projects,” in *Proceedings of ICEC CELDA, 2007,* 2007.

[22] A. Kukulska-Hulme, “Mobile usability in educational contexts: what have we learnt?,” *The International Review of Research in Open and Distributed Learning,* vol. 8, no. 2, 2007.

[23] K. Peters, “m-Learning: Positioning educators for a mobile, connected future,” *The International Review of Research in Open and Distributed Learning,* vol. 8, no. 2, 2007.

[24] T. H. Brown, “Towards a model for m-learning in Africa,” *International Journal on E-learning,* pp. 299-315, 2005.

[25] J. Taylor, “Evaluating mobile learning: What are appropriate methods for evaluating learning in mobile enviroments,” *Big issues in mobile learning,* pp. 25-27, 2006.

[26] J. Traxler, “The evolution of mobile learning,” *The evolution of mobile teaching and learning,* pp. 1-14, 2009.

[27] C. B. L. &. J. R. Chou, “A case study of mobile learning pilot project in K-12 schools,” *Journal of Educational Technology Development and Exchange,* vol. 5, no. 2, pp. 11-26, 2012.

[28] M. Sharples, “Big Issues in Mobile Learning,” in *Report of a workshop by the Kaleidoscope. Network of Excellence Mobile Learning Initiative*, 2006.

[29] C. &. S. D. O'Malley, Tangible Technologies for Collaborative Storytelling, Birmingham, 2002.

[30] P. Körtesi, “Computer aided teaching of Mathematics and the Pilot-courses in ECADL,” in *International GeoGebra Conference for Southeast Europe Međunarodna GeoGebra Konferencija,* Novi Sad, 2011.