

Use of GeoGebra in primary math education: a theoretical approach

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Abstract. GeoGebra as cost-free, multi-platform mathematics software, dynamically connecting concepts in geometry, algebra and calculus is applied in different school's levels, and primary school is no exception. The aim of the paper is to present a theoretical approach of application of GeoGebra in Lithuanian's primary math education. It analyzes features of GeoGebra, its possible integration into primary school education according to Educational Plan and Programme. Also some examples how this software can be effectively incorporated into teaching and learning are presented. With a view to evaluate GeoGebra's suitability to primary education primary school teachers were interviewed and results of that exploratory study are presented. Also the study seeks to identify the conditions to successfully support teachers in using GeoGebra and learning objects prepared by it in their teaching process including organisational and technical support required.

Keywords: GeoGebra, primary education, math, ICT, teaching and learning.

Introduction

This paper investigates use of GeoGebra [3] as a tool in primary math education from teachers' perspective. GeoGebra belongs to a group of dynamic geometry software that supports constructions with points, lines and all conic sections [1]. One of the most powerful and the most widely recognized didactical components of these systems is visualization [5]. Although some authors have recognized advantages and disadvantages of this system [4, 7, 8], therefore application of it depends on many reasons and factors that affect teachers decision to utilise GeoGebra and learning objects prepared by it in their teaching process. The main purpose of this study is to examine the reasons/factors affecting teacher's decision to utilise GeoGebra and learning objects prepared by it in their teaching process. Also the study seeks to identify the conditions to successfully support teachers in applying GeoGebra and learning objects prepared by it in their teaching process including organisational and technical support required.

1 GeoGebra as a tool for math education

GeoGebra is free algebra, geometry and calculus software developed in the University of Cambridge Education Institute although an initiator was a lecturer Markus Hohenwarter from Johannes Kepler University of Linz in Austria. This software which

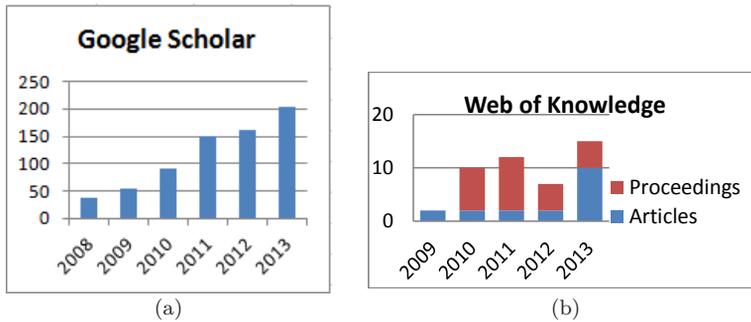


Fig. 1. Distribution of scientific papers on GeoGebra from 2008 to 2013 in (a) Google Scholar and (b) Web of Knowledge.

was awarded a number of awards such as EASA 2002 (European Academic Software Award), Learnie Award 2003 (Austrian Educational Software Award), German Educational Media Award Trophées du Libre 2005, <...>, has been used by several countries in their education systems [6]. From 2010 Lithuania is actively involved in “The Nordic&Baltic GeoGebra Network”¹ which is collaboration between teachers, teacher educators and researchers in mathematics education (there were five conferences organized, one of them in Vilnius, Lithuania) with the aim of sharing materials and exchanging experiences concerning the use of ICT in the teaching of mathematics (including also particularities of primary math education) with emphasis on the GeoGebra software. In comparison to others dynamic geometry software GeoGebra has several advantages: first of all, it is free, next there is the support of many languages and online lessons are available in these languages. Another very important thing is that this tool can be installed in different kind of computers with different operating systems, e.g. Windows, Mac OS, Ubuntu, it already has mass installation on multiple computers and works on mobile technologies, i.e. tablets [3]. It is very important because usage of mobile technology promotes collaboration, since it stimulates face-to-face social interaction between learners that is really important in modern teaching and learning process.

According to data obtained from an academic citation indexing and search service, which is combined with web linking and is provided by Thomson Reuters (Reuters) and Google Scholar (Google) it can be concluded that research on GeoGebra is growing (Fig. 1). The search was done for each period from 2008 to 2013 using these keywords: geogebra, primary school, primary math education.

Looking at the GeoGebra from the perspective of classroom learning activities GeoGebra can be applied in three different kinds of activities, mainly for demonstration, exploration and modelling, creation and experimental work.

*Demonstration*² – learning objects created with GeoGebra are presented by teachers to learners. A teacher can use different sliders to show learners 11 different patterns of cube. A discussion can be organized with learners revising the material about some features about the cube or after some learners’ activities they can be introduced to different ways, how to represent other patterns of cube (Fig. 2).

¹ <http://nordic.geogebra.no/>.

² <http://www.geogebraTube.org/student/m19165>.

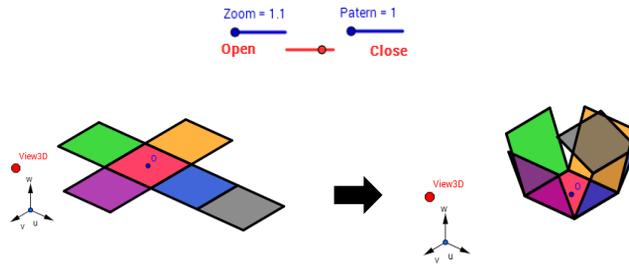


Fig. 2. Examples for learning activity with GeoGebra – demonstration.

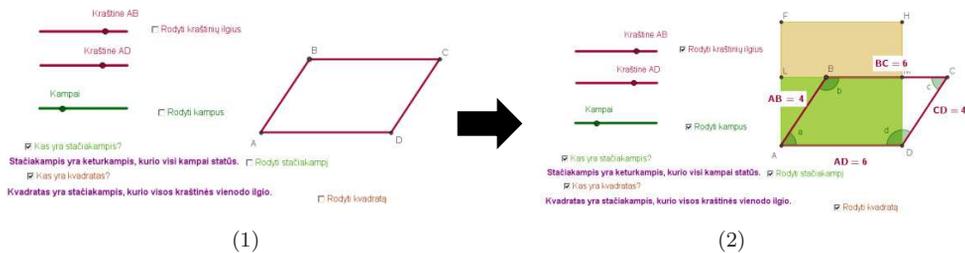


Fig. 3. Examples for learning activity with GeoGebra – exploration and modelling. (1) Differences among parallelogram, rectangle and square.⁴

*Exploration and modelling*³ – learning objects are prepared so that learners have to examine and find relationships, discover some theory or consistent patterns of math objects. On official site of GeoGebra there is a lot of learning material that could be useful for exploration and modelling, e.g. (1) represents dynamic learning object using which learners should explore differences among parallelogram, rectangle and square. Although topic of learning object is broader than Educational Plan and Programme of primary education, but it could be effective for gifted learners (Fig. 3). In example (2) learners are able to practise or quickly revise subtraction in dynamic environment (see footnote 3).

Creation and experimental work – learners are working with GeoGebra in order to create meaningful learning material or produce something new.

GeoGebra supports several tools which could be used effectively by learners, e.g. they are introduced to symmetry. In their practical work, they can be asked to draw some symmetric and asymmetric pictures comprising different shapes. After that using GeoGebra’s tool for analysis of symmetry learners can easily experiment not only with their drawings but also with other pictures, e.g. of the nature.

Learners could draw and explore the axes of symmetry of a flower (Fig. 4).

In general, according to [8] there are four aspects that mathematical software (including GeoGebra) can offer to the process of mathematics teaching and learning:

1. *Multiple display options* – the availability of different ways of displaying mathematical content, e.g. symbolic to graphic. Demonstration and visualisation and

³ <http://tube.geogebra.org/student/b72936#material/20311>.

⁴ Learning objects presented in Figs. 3 and 4 were created in Lithuanian by primary education experts during activities of the project „Development of Primary Education“.

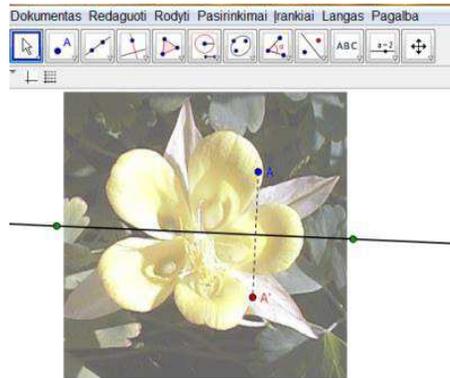


Fig. 4. Example for learning activity with GeoGebra – *creation and experimental work*.

- clarity have always been very important for understanding mathematical ideas during the process of learning and problem solving;
2. *Experimental work* – the possibility of students using experimentation in order to gain new knowledge, ideas and problem solving approaches;
 3. *Elementarisation of mathematical methods* – for example, GeoGebra as a construction tool has all the abilities demanded from a suitable drawing/designing software, which are very important for teaching constructive geometry;
 4. *Connectivity* – opening new opportunities for shared knowledge construction and for learner autonomy over their mathematical work.

2 Use of GeoGebra in primary math education in Lithuania

Recently in Lithuania very big attention was paid to development of primary education. Some big projects were and are being implemented by the Centre of Education Development at the national level. During these projects innovative methodologies were presented and practised, also in order to engage students, to facilitate their learning, to promote creativity, collaborative learning it has been looking for ICT suitable for primary education.^{5,6} In order to achieve aforementioned aims several tools were proposed for primary math learning and one of them was GeoGebra because of several aspects mentioned in Section 1. The goals of mathematical courses in primary education in Lithuania can be found in the Educational Plan and Programme [2] issued by the Ministry of Education and Science of the Republic of Lithuania. On the ground of this document, with the use of computers in classrooms, the following goals appear in the foreground: (1) focus on application, modelling, authenticity and problem solving; (2) emphasis on the presentation aspects and interpretation in mathematics; (3) focus on the appropriate concept formulation; (4) focus on ability to learn mathematics; (5) interdisciplinary. Table 1 represents some examples how GeoGebra can be used in primary math education. Although in GeoGebra there are five different perspectives, therefore in primary education mostly can be used only

⁵ <http://www.upc.smm.lt/projektai/tobulinimas/apie.php>.

⁶ <http://www.upc.smm.lt/projektai/modelis/>.

Table 1. GeoGebra and primary math education in Lithuania.

| GeoGebra perspectives | Math subject | Examples |
|-----------------------|---|--|
| Algebra and graphics | Numbers and calculations Algebra Measurements | To explore, how increases or decreases number by units, many times the number, e.g. decreased, etc. by representing them in dynamic line of numbers. To solve simple equations, inequalities, etc. |
| Elementary geometry | Geometry Numbers and calculations Measurements | To plan and understand orientation in a plane by analyzing main concepts to the right, to the left, above, etc. To describe position of several objects. To explore notations. To focus on the appropriate concept formulation (triangle, rectangle, square, etc.) |
| Tables and graphics | Numbers and calculations Algebra Measurements Statistics | To explore data, to influence them by changing them, to represent it by diagrams |

three because of both educational plan and programme of mathematics in primary education and complexity of GeoGebra.

During seminars for primary school teachers⁷ (activities of the project “Development of Primary Education”, i.e. 10 public discussions with educational communities of different regions of Lithuania (200 participants) were organized in order to know the situation of practical, problem solving and creativity and how to enrich opportunities of such situation including use of ICT), 15 teachers having expert qualification were interviewed about the use of GeoGebra in primary school having in mind teaching and learning activities described in Table 1. Experts were asked to fill in a form with twelve questions. The main result of that interview was the confirmation that teachers are interested to use GeoGebra in their work for demonstration activities, but they need more knowledge and practise for other activities, i.e. for both exploration and modelling and creation and experimental work.

3 Concluding remarks

In order to have efficient teaching and learning first problem of teacher attitudes to ICT tool should be recognized. Data obtained from scientific literature show that research on GeoGebra usage in primary education is growing, therefore, the aim of the paper was to present a theoretical approach of application of GeoGebra in Lithuanian’s primary math education. Some features of GeoGebra were analyzed and possibility to integrate it into primary school education according to Educational Plan and Programme was proposed. Also some examples how this software can be effectively incorporated into teaching and learning process were presented. With a view to evaluate GeoGebra’s suitability to primary education 15 primary school teachers-experts were interviewed and results of that exploratory study were discussed in short. Results of the interview showed that teachers are not ready to use GeoGebra as a tool for creating, but they are enthusiast to apply qualitative learning objects prepared by it in their work for demonstration activities. On the ground of the experiment done, next studies will be performed in order to identify the conditions

⁷ <http://ugdymotobulinimas.jimdo.com/renginiai/>.

to successfully support teachers in using GeoGebra and learning objects prepared by it in their teaching process including organisational and technical support required.

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REZIUMĖ

Teoretinės Geogebros taikymo pradiniam ugdyme perspektyvos

I. Žilinskienė

Straipsnyje nagrinėjamos teorinės Geogebros taikymo pradiniam ugdyme perspektyvos, pateikiami konkretūs Geogebros taikymo pradiniam ugdymui pavyzdžiai. Trumpai aptariami atlikto interviu su pradinių klasių mokytojais rezultatai.

Raktiniai žodžiai: GeoGebra, pradinis, ugdymas, matematika, IKT, mokymas ir mokymasis.