GeoGebra as a motivational tool for teaching and learning in Slovakia

Ján Gunčaga and Janka Majherová

Abstract: In this article we present several possibilities of the use of GeoGebra in education. We present Slovak GeoGebra Wiki as a tool to share teaching materials. We show some examples of this use in subjects of mathematics, physics and computer science. These works are connected to the goals described in new Slovak Curriculum ISCED 2 for education at the lower secondary education level.

Keywords: Slovak, mathematics education, computer science education, physics education, GeoGebra, secondary education

1. INTRODUCTION

According to Oldknow and Taylor (2003) we can identify at least three reasons to promote an integration of Information and Communication Technologies (ICT) in the teaching process of mathematics at schools.

- **Desirability**: The use of ICT may stimulate pupils' motivation and curiosity and encourage them to develop their problem-solving strategies. Regarding teachers, the use of ICT can improve their efficiency, provide more time to address students individually, or stimulate rethinking of their approach to teaching and understanding.
- **Inevitability**: Many fields of publishing have moved from a printed to an electronic form. This fact applies to conference proceedings, reference works such as encyclopaedias, small-circulation textbooks, special journals, etc.
- **Public policy**: Slovak National Curriculum ISCED 1, 2 and 3 classifies Mathematics as a school subject, which is a part of the group called Mathematics and Working with Information.

During the teaching process, ICT support the development and implementation of high-quality teaching and assessment materials. An important aspect of ICT-aided education is visualization. Within the framework of mathematics education, ICT promotes mathematical communication among teachers and students in the following ways.

- ICT provides an effective medium for communicating one's method for solving mathematics problems and discovering / communicating structures of various mathematics models.
- ICT promotes the visualisation of relationships within and among various mathematical models, enabling students and teachers to develop new results and new connections in other fields within and outside of mathematics.
- ICTM supports the building of various mathematical competences, including basic science, communication, and digital competences.

GeoGebra supports the realization of the above concerns. This software connects features of computer algebra (CAS), interactive geometric software (IGS) and spreadsheet. GeoGebra provides this functionality within an intuitive, user-friendly interface. The software provides teachers and students with a method for authoring dynamic HTML websites with interactive pictures (see Hohenwarter & Lavicza, 2010). Materials developed by GeoGebra may be freely uploaded and hosted on GeoGebraTube[1] or GeoGebra Wiki.[2] The latter contains materials created for Slovakian school students.[3] The materials and applets available at the aforementioned site makes use of the interactivity and dynamical character of GeoGebra. Moreover, the materials follow the Slovak curriculum from geometry through calculus (e.g., exponential and logarithmic functions, cubes, hexagonal prisms, constructions of triangles and parallelograms). Naturally, the website contains also materials for teaching physics and computer science.

2. SOLVING GEOMETRICAL TASKS IN GEOGEBRA

The new Slovak curriculum ISCED 2 for lower secondary level includes multiple educational competencies for teaching of geometry. For instance, pupils should be

Manuscript received November 7, 2011; revised March 14, 2012; accepted May 2, 2012.

Ján Gunčaga is a faculty member in the Department of Mathematics at Catholic University in Ružomberok, Hrabovská cesta 1, 034 01 Ružomberok, Slovakia (email: jan.guncaga@ku.sk). Janka Majherová is a faculty member in the Department of Informatics at Catholic University in Ružomberok, Hrabovská cesta 1, 034 01 Ružomberok, Slovakia (email: janka.majherova@ku.sk).

This research was supported by KEGA 001UJS-4/2011

[1] www.geogebratube.org

[2] http://wiki.geogebra.org/en/

[3] http://www.geogebra.org/en/wiki/index.php/Slovak

Fig 1: Slovak version of GeoGebraWiki

able to construct and describe the basic geometrical figures or to specify properties of their particular elements (relationship of sides, diagonal, triangle inequality and so on). They should know basic geometrical transformations, axial and central symmetry, the relationship between figure und its picture in transformation and how to analyse and solve application geometrical tasks with a use of mathematical know-how.

Pupils obtain a geometric imagination as an ability to explore geometric figures and their properties, to abstract geometric properties from the particular objects, to have a perception of geometric shapes, and to be able to imagine geometric figures and their relationships.

Since the new curriculum in mathematics has been introduced in Slovakia only recently, few textbooks have been developed with these new standards in mind. The materials from the Slovak Wiki have been developed to help teachers (and their students) learn more about these new instructional expectations. As we develop teaching materials on the Wiki, our aim is to collaborate with current and future school teachers and their students. Some examples can be also found in works by Billich (2008), Tkaĉik (2007) or at `http://geogebra.ssgg.sk`.

Now we can present some works, which are applicable in teaching of geometry. These examples have been prepared by students from the training programs for mathematics at secondary school. The materials are focused to explain new notions with support of interactive GeoGebra applets. The first example belongs to the framework of teaching of the plane geometrical figures (parallelograms). Figures 2 and 3 highlight an applet that aid in the construction of a parallelogram and rhomboid with some sides and angles given. The sketch that we used to generate the figures is available for download.[4]

[4]http://www.geogebra.org/en/upload/files/Slovak/Ranostaj/Prezentacia.html

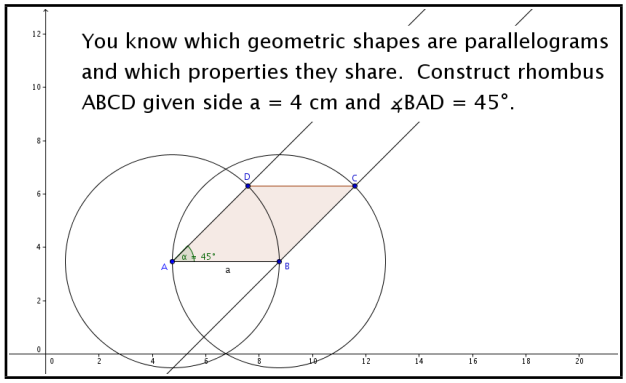

Fig 2: Parallelogram construction sketch

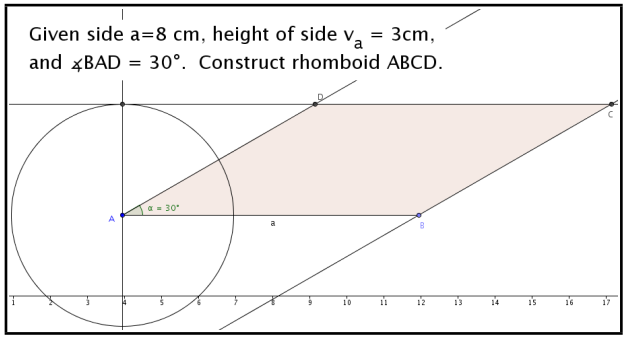

Fig 3: Rhomboid construction sketch

The second example describes how to draw a cube in the plain using the rule that the side edges have the half length compared to the front edges (fig. 4). Playing the construction is an important advantage in this teaching unit (Kopáčová, 2003).

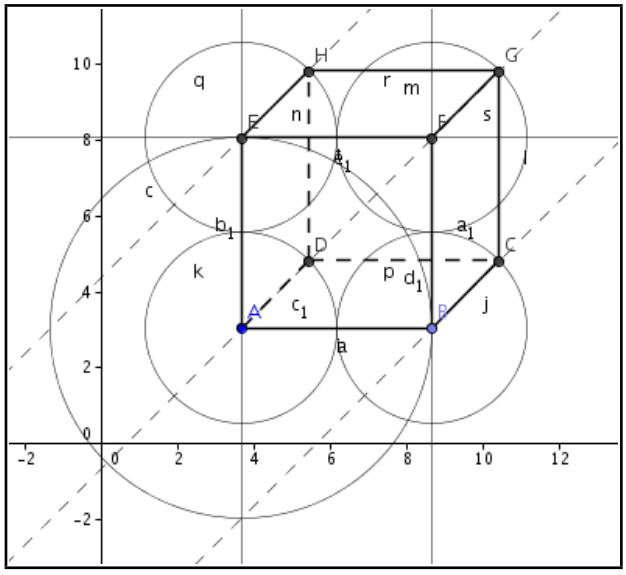

Fig 4: Cube construction sketch

GeoGebra can be used as an effective tool to motivate pupils as it can visually represent a variety of mathemati-

cal notions and their relationships in a dynamic way. Within the interdisciplinary relationships, we can use GeoGebra also in the subjects of computer science or physics in the secondary education.

3. GEOGEBRA IN TEACHING OF COMPUTER SCIENCE AND PHYSICS

In our computer science courses, we start with an introduction of the GeoGebra program - first introducing students to use of the toolbar as well as the graphics and geometric windows. In our courses, we assume that students are familiar with fundamental principles of graph theory and can construct an algorithm for a given problem and write a solution using symbolic language (Kutna & Palasthy, 2009). After we familiarize our students with the GeoGebra environment, we pose the following related tasks.

- Travel over all the edges of graph by single path, which starts and finishes in the same vertex. Write a solution as a sequence of vertices (refer to Figure 5).
- Find the shortest path in a graph such that all the vertices are connected (refer to Figure 6).
- Construct a simple algorithm which searches for a way through a labyrinth (refer to Figure 7).

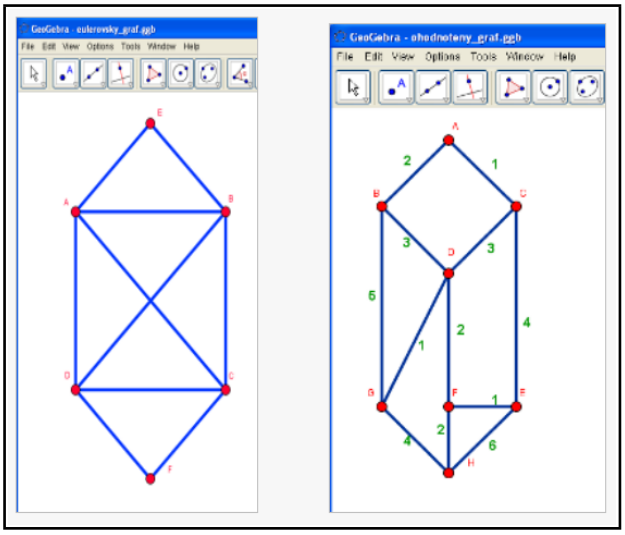

Fig 5: Graphs in GeoGebra

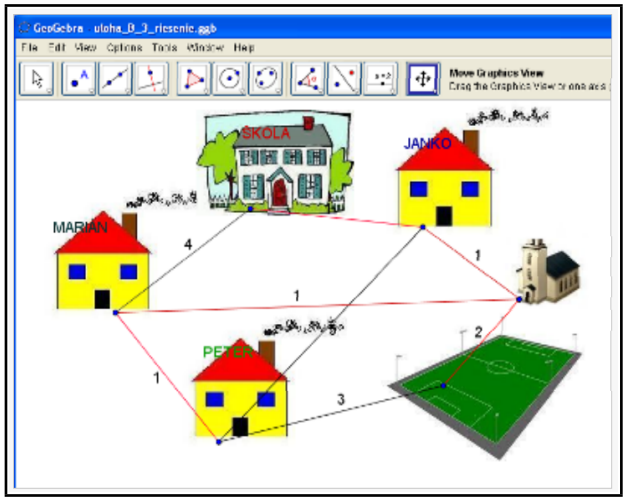

Fig 6: Shortest path in graph as represented in GeoGebra

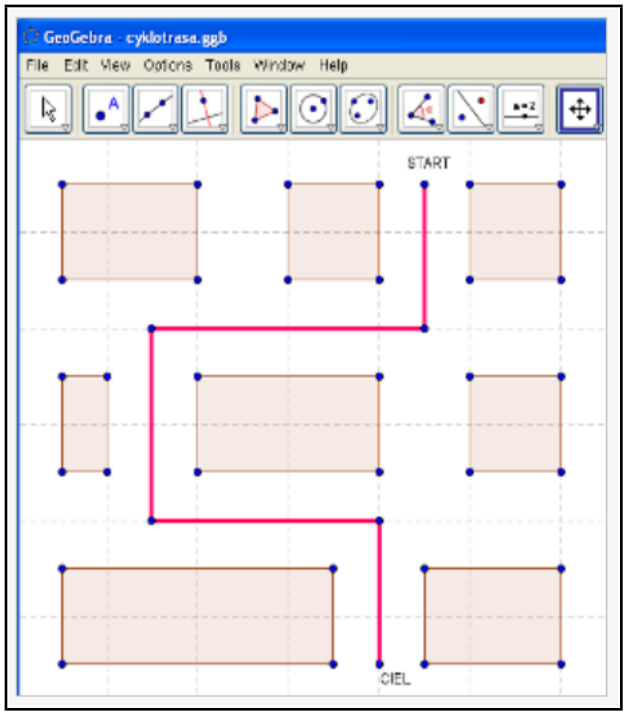

Fig 7: GeoGebra labrynth sketch

Our pupils experienced little difficulty working with GeoGebra on the aforementioned tasks. They were able to discover new features of the software without prompting from the instructor, including options to change coloring, background and style. The assigned tasks were interesting for the pupils, who handled them without major trouble.

In physics, several educational competencies of the pupils are also defined in the Slovak curriculum ISCED 2 for lower secondary level. The pupils should be able to: explain the force as a form of mutual interaction of two objects advance in the analysis of different notions, effects (physical parameters, laws), find a relationships between the physical parameters.

In Figure 8 we present the representation of a composition of non-parallel forces (notice here a connection to pupils' knowledge of mathematics). Consequently this composition is used on Figure 9 to illustrate a motion on the inclined plane (available online[5]).

[5]http://edu.gsa.sk/jancek/?id=40200

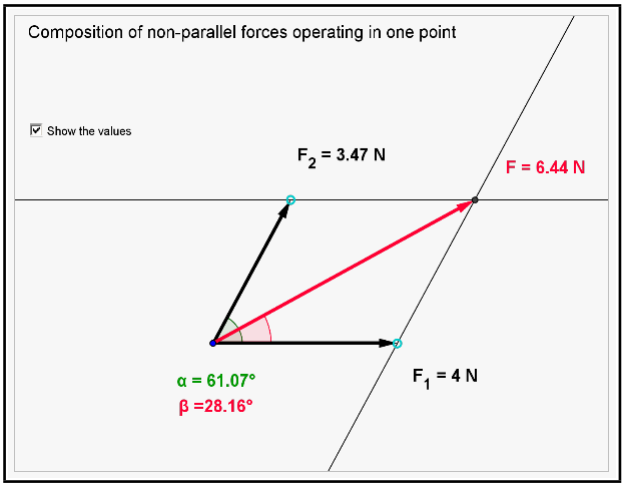

Fig 8: Composition of forces

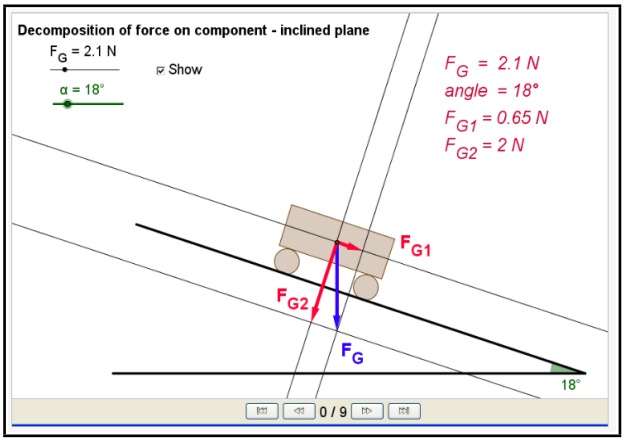

Fig 9: Motion on the inclined plane

4. CONCLUSION

There are numerous possibilities for a visualization and simulation processes using a computer while teaching of mathematics, computer science and physics. Graphical possibilities of didactic software allow students to work with models of different objects. Students can apply knowledge gained in learning stage while looking for solutions of different problems. Moreover, they can visually observe the result and thus understand and adopt basic concepts and notions more easily. Creation of the model and its visualization by computer allows pupils to gain specific experiences regarding the use of mathematics, physics and informatics in a practical life.

The relationships between mathematics, informatics and other subjects, which are supported by GeoGebra, are a very important part of integration of ICT in education. In our paper we describe different examples of using GeoGebra in mathematics, informatics and physics education in lower secondary level. Materials in GeoGebra can effectively assist teachers in supporting the pupils' cognitive process. Pupils can develop its formal and logical reasoning, cooperation and communication. They will gain skills that are necessary for the research work, e.g., an ability to implement a simple research project, to formulate a problem, to look for the solution and cause context, and to learn how to use various methods of problem solving.

REFERENCES

Billich, M. (2008). The use of geometric place in problem solving. In *Teaching Mathematics: Innovation, New Trends, Research*. Ružomberok: Catholic University Press, 7-14.

Baláková, G. (2011). *The use of program GeoGebra in subject computer science*. Ružomberok: Catholic University Press.

Hohenwarter, M., & Lavicza, Z. (2010). Gaining momentum: GeoGebra inspires educators and students around the world, In *GeoGebra The New Language for the Third Millennium 1*(**1**). Galati, Romania: Zigotto Printing & Publishing House, 1-6.

Johnson, D. W., & Johnson, R. T. (1975). *Learning Together and Alone*. Englewood Cliffs, NJ: Prentice-Hall.

Kopáčová, J. (2003). Investigative activities - student skills development tool. In *Paths of democracy in education*. Bratislava: Comenius University Press, 147-150.

Körtesi, P. (2009). GeoGebra Institute of Miskolc Didactical Research Group of the Department of Analysis of the University of Miskolc in the framework of the European Virtual Laboratory of Mathematics. In *IMEM 2009*. Ružomberok: Catholic University, 582-585.

Krech, G., & Krech I. (2009). On some nontransitive relation. In *Proceedings of International Conference Presentation of Mathematics 2009* (ICPM'09). Liberec, Czech Republic.

Kútna, A., & Palásthy, H. (2009). Application of information technology in teaching mathematics. In Billich, M. (ed.), *Mathematica III*. Ružomberok: Catholic University, 47-52.

Oldknow, A., & Taylor R. (2003). *Teaching Mathematics using Information and Communications Technology*. New York, New York: Continuum.

Tkačik, Š. (2007). Why logarithms? In *Matematyka XII prace naukowe*. Czestochowa, Poland: Akademia im. Jana Długosza (AJD), 429-434.