Visual Methods in Computer-Assisted Instruction, GeoGebra software, e-materials and teachers training

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Abstract

It is generally reported that reluctance in using advantages of visual approach in mathematics education, in order to support meaningful learning is the result of the low status accorded to visual aspects of mathematics in the classroom environment. However, despite an increase in the availability and potential benefits in learning, research shows that computers and visual approach in mathematics instruction are underused in many schools. Therefore, the aim of the paper is to improve the meaningful use of visual methods and computer-assisted instruction in primary and secondary schools by pointing out all available resources as e-materials, workshops, research results and technical assistance for teacher's professional development.

Key words: mathematics, visualization, teacher's training.

MSC: 97D40, 97D70

1. Introduction

The issue of underuse of visual approaches to support meaningful learning is especially connected to symbolic representation inmathematical topics, where students become reluctant to engage with visual modes of learning according to (Presmeg& Bergsten 1995; Healy &Hoyles 1996).

It is clearly that visualization can't be used as 'panacea' for each classroom situation since an intuition about a generalization involves more than observed evidence. For example, althoughone calculus images supported student's level of mathematical functioning, occasionally theseimages did more to obscure then to explain (Aspinwall, Shaw, and Presmeg, 1996). This type ofimagery can be a major issue in constructing mathematical concepts. Some of the reasons are: the belief that visual proof is not 'real' mathematical proof, the algebraic mode instead of the graphic or visual is more commonly used on calculus tests and the belief held by both teachersand students that doing calculus is skillfully manipulating numbers and symbols according to (Aspinwall, Shaw and Presmeg 1996).

There are many authors as Dreyfus (Dreyfus, 1991) which argues that the status of visualization in mathematics education should and can be upgraded from a helpful learning approach to a fully recognized tool for learning. There are many effective examples which demonstrate the power of visualization in mathematical reasoning that have since become a regular feature in publications of the Mathematical Association of America.

On the other hand, a role of visual/nonvisual teacher's model is one of the crucial causes of this problem. The visual teachers constantly made connections between the subject matter and other subjects, sciences and the real world despitenonvisual teachers. As presented, the basic reluctance of students to

use visualization in mathematics is the result of the low status accorded to visual aspects of mathematics in the classroom environment.

Following Presmeg, mentioned role of teacher is crucial for constructing students' knowledge, since visualization includes processes of constructing and transforming visual mental imagery and spatial information that may be implicated in doing mathematics (Presmeg, 1997b) where a visual image is taken to be a mental construct depicting visual or spatial information and a visualizer a person who prefers to use visual methods when there is a choice.

2. Visualization in computer-assisted mathematics instruction

Systematic research on computer-assisted instruction suggests that there are a small but positiveeffects in comparison to traditional teaching (Blok, Oostdam, Otter & Overmaat, 2002; Torgerson & Elbourne, 2002). However, despite an increase in the availability and potential benefits of learning, research shows that computers are under-used in many schools and that thepotential of computer technology is not implemented (Abrami, 2001). Therefore, the main objective of the paper is to improve the use visual methods and computer-assisted instructionin primary and secondary schools, by providing information on available professional development for teachers in the use ofnew technology, workshops, and technical assistance.

Computers impact to visual reasoning in mathematics education is undeniable and learner's use of visualization through dynamic geometry software which facilitates visualization processes hasbeen discussed over the years in many papers. Widening effects of computer technology in mathematical visualization prove that this methodology have affective attributes in mathematicalproblem solving processes. This approach represents powerful engine not only in mathematicaltopics such as geometry and trigonometry but also in algebra, analyses, etc. There have also beenreported many special advantages of computer software usage that encourages dynamic visualization according to (Hohenwarter& Fuchs 2004).

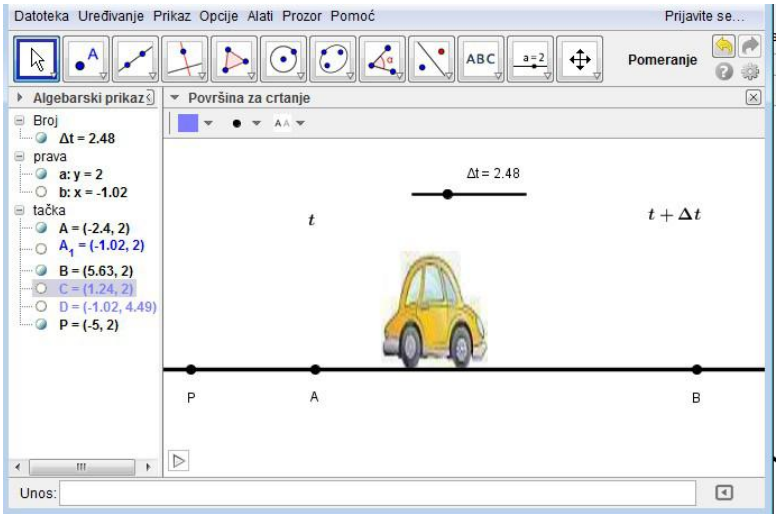

Figure1. *The differential concept*

There is an increasing number of different educational software that contributes easier learning mathematics among students, especially when it comes to software for dynamic geometry. Oneof them is the GeoGebra software which is a multilingual software package dedicated to the study of Euclidean geometry, algebra, analysis, statistics and other mathematical fields as well asconnecting it with other mathematical models of the nature sciences. GeoGebra is used for interactive approach in mathematics

education through modeling, picking the right function, clicking checkboxes, moving sliders, etc. which make this software adequate for strengthening math skills and visualization of various abstract concepts as shown in the *Figure 1*.

3. Professional support for teachers in math instruction

In order to overcome the problem of low integration of visual methods and ICT in teachingmathematics, Regional Center for Professional Development in Education Čačak, GeoGebra Center Belgrade and the Institute for the Advancement of Education have supported the ICT workshop for math teachers. One of the goals of the accredited workshop is the professional development of math teachers and strengthening their ICT skills through training in the use of ICT and software package GeoGebra in interactive workshops and designing educational e-materials.

Technologies that were used in seminar included: laptops, computers for participants and appropriate software package in cooperation with the participating schools. Workshop includedtopics such as the integration of Web resources in lessons (e.g. use of GeoGebra software) in order to allow the dynamic manipulation of equations, visualization of geometry, algebra, analysis, etc. as well as teacher training for designing educational materials. Technical and pedagogical assistance were provided to teachers by face-to-face and indirect communication - in the form of sharing ideas, suggestions and examples of good teaching practices via e-mail and social networks.

Aims of the workshop are fostering teacher'smotivation and ICT skills in general, as well as creating publicly availableand interactive educational toolkit. In order to make it easy for teachers to incorporate these lessons in their instruction, educational materials for workshops, seminars andmaterials for innovative math lessons have been designed, as shown in *Figure 2*.

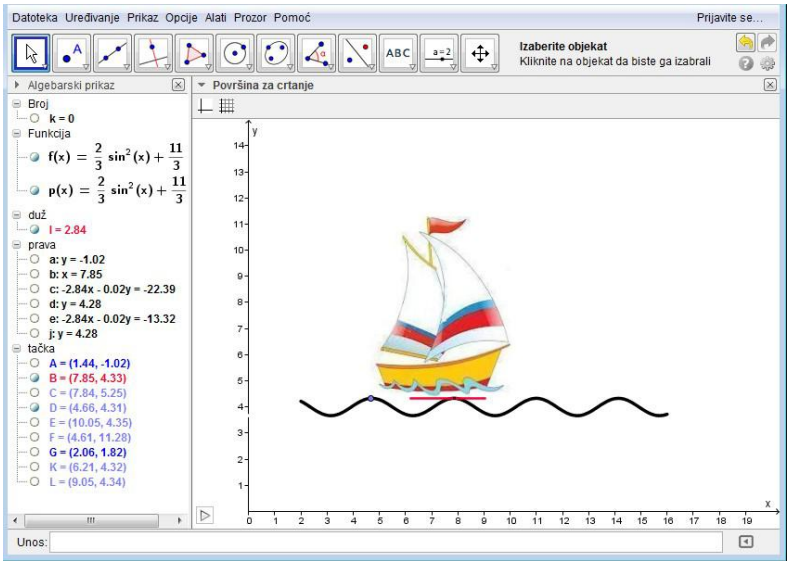

Figure 2. *Differentiable functions*

As a way of overcoming the anxiety of reading, learning and understanding mathematical literature that includes theorems and proofs, created e-materials offers numerous animation ofthese and similar problem-solving concepts as motivational both educational tool. The aim of created e-materials is to provide material which will encourage learners to use visualization, helpthem to overcome the difficulties and at the same time to be adequate for incorporating in classroom activities. In order to foster students motivation and attention, new technologies and media are involved in way of creating mathematically significant images, whether dynamic or not, as important tool for learning by visualizing and connecting

different mathematical topics (analysis, analytic geometry, trigonometry, etc.). Due it ispublicly available and written in Serbian, there are no language barriers for its usage in the countries in the region according to (Jezdimirovic, 2013; Jezdimirovic, 2014).

4. Evaluation of carried out professional teacher's development

Evaluation of the workshop (Jezdimirovic, Radovic&Maric 2014) indicate that teachers have a positive attitude towards the use of visual methods andICT in mathematics instruction, regardless of the number of years of experience. Furthermore,the respondents believe that it is desirable to use innovative teaching aids. Most participants agree with the statement that there isn't an adequate number of interactive educational materialsfor teaching mathematics in Serbian language. Furthermore, participants proposed more seminarsand workshops as professional support in instruction as well as interactive whiteboard, GeoGebra site in Serbian, GeoGebra software package and active use of computers in everydaymathematics instruction.

Results also indicate that the willingness and motivation to continuetheir professional development in this area show mainly teachers from primary schools comparedto teachers of mathematics in secondary schools. At the end of a one-day training a large number of teaching units have been created and participants also reported further sharing created interactive e-materials on their own web sites,blogs, social networks, etc. Designed materials can be implemented in digital classrooms, for playful activities, classroom's interdisciplinary approach as well as the creative interactive visual workshops, etc.

5. Conclusion

The issue of available interactive educational materials in Serbia is the lack of useful web pages and programs in Serbian that could be complementary pedagogical tool; secondly, teachers do not have adequate training in the use of such tools, evenif there are enough available. Despite the variety of Institute for the Advancement of Educationlong panel discussions and seminars, teachers still needed the most professional development inthe use of new technologies in the workplace. Empirical data of the research show that strategies for overcoming stress, such as increased training, exercise priorto use of ICT, change the style of teaching and training must be more efficient and therefore should be encouraged.

Impacts of created educational materials, which are be available and outside the classrooms, by using smart devices or tablet devices, to students' motivation and achievements are left to be revealed in the future study - all is needed is to be used in the mathematical instruction.

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