Research on Interactive Geometry Visualization for Secondary School

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Abstract

Constructionist ideas can be effectively realized in mathematics lessons. The new technologies such as dynamic geometry improve student’s skills. However, there is still a strong focus on mathematical knowledge acquisition (Dagiene et al., 2007).

The research is based on visualization with dynamic geometry. The dynamic geometry is relatively complex for a math teacher for several reasons: first, a dynamic geometry construction is based on a hierarchy and to construct a sketch, teachers must have (or acquire) new skills of developing algorithms and programming by geometry; second, most tools of dynamic geometry software are rather complex for the teacher (Hohenwarter et al. 2009). Some scientists see quite the other problem of information technology: the usage of digital tools depends on the teacher’s disposition. If the teacher uses active learning and constructive methods of teaching, he/she is willing to use the dynamic geometry for teaching, if the teacher uses traditional teaching methods, he/she is not willing to use the dynamic geometry for teaching (Stols, Kriek, 2011).

These studies have inspired the ideas how to develop an approach making the mathematics studies easier for both students and teachers and how to attract teachers to use dynamic geometry software (or other creative software for mathematics).

The aim of research arises here: to construct method (or model) of interactive visualization of secondary school geometry. Some steps have to be done to fulfil the aim:

- To analyze what is done for interactive geometry visualization in the mathematics education.
- To create model of constructionist learning with dynamic geometry software and to define the place of research in it.
- To chose criteria of interactive geometry visualization to prepare qualitative interactive images for learning and teaching secondary school geometry.
- To construct method of interactive geometry visualization with dynamic geometry.
- To realize method of interactive visualization and to do pedagogical experiment on it to ensure that interactive images improves student’s skills of geometry.
- To evaluating the set of interactive images created by offered method using the MCDA theory.

To realise these tasks we use systematization and a comparative analysis for analytic part; the construction method for investigation of interactive visualization
method; pedagogical experiment; the obtained results of experiment were processed using the statistical package SPSS and descriptive statistics.

**Keywords**
Interactive visualization, dynamic geometry, secondary school, skills

**INTRODUCTION**
The process of learning moves into the computer world very fast. The new technologies such as notebooks, multiBooks, iPad, iPhon and other appear in the schools. Practice shows the most of teachers have not assimilated computer usage when they have to acquire new abilities of usage of new technologies. It is the challenge for most teachers to use such computational tools in the lessons.

Mathematics is one of subject which requires visualization for explanation theories, methods and problems. And these visualizations can be implemented by computational tools. Dynamic geometry software is one class of tools for learning mathematics. There are done some studies of the usefulness of dynamic geometry in learning process (Oliver, 2000; Patsiomitou, 2008). However secondary school teachers rarely use dynamic geometry in their lessons. The technologies changes much faster than teachers manage to use them. And often teachers are hurry to prepare students to the exam and cannot spend more time to learn technologies themselves and to prepare students to use them. A “bridge” between tools and teachers has to appear here.

The way of usage of dynamic geometry tools is offered in this paper. The author calls this way – *method of interactive visualization*. The main idea is to prepare interactive content for teaching and learning. Here two different domains have merged: technology and mathematics education. The science problem is how to merge them. A analyze of literature, practice works and projects let authors to answer to this question: it have to be found intermediate part between technology tool and mathematics teacher. The method of creating learning resource in dynamic geometry software is presented in this paper. The technological and methodological criteria were chose to prepare qualitative and easy to use learning resource. The results of experiment on realization of method of interactive visualization are described in this paper.

**DISCUSSION**
**Constructionist learning**
One of the well-known approaches to upodate constructionist learning is presented by A. Baytak (2011). He presents the model of constructionist learning by game design, where he declares four steps: planning, designing, testing, and sharing (Baytak, 2011). A. Baytak (2011) model was extended and adapted for learning geometry with dynamic geometry (Jasute, Dagiene, 2012a). The research is related with two stages of the model: analyzing and formulating (Figure 1).

The model illustrates five steps of learning: 1) analyzing – a student moves free geometric objects in the pre-created sketch and observes what is moving, changing, what properties remain the same, etc.; 2) formulating – a student formulates concepts, properties, axioms, theorems according to his experience of dynamic drawings; 3) creating a drawing – when a student analyzes the drawing and gets some knowledge by his experience, he can create some drawing; 4) creating models – here we mean that a student has got or, in some case, plans to make a realistic object (box, furniture, room, yard and etc.) and creates a model (plan, tile, etc.) of this object using dynamic geometry and 5) a student shares and discusses his drawing with other students. In all the steps a student constructs his own internal
knowledge by interactions with the external learning environment (teachers, students, literature, etc.). The whole process is associated with the information technology (in our case, dynamic geometry software).

Figure 1: The Extended Constructionist learning model

Method of interactive visualization
There are three steps to create qualitative digital learning tool: first, to analyze curricula and distinguish topics for visualization, second, to write scenarios for each topic, third, to create collection of learning objects (Dagiené, Jasutiene, 2006). Here two different domains have merged: technology and mathematics education.

The goal of research is to prepare a method which helps to construct digital learning resource with interactive images and dynamic sketches for learning mathematics. The three important tasks are held: 1) to prepare technically realizable and usable resource, 2) to prepare recourse easy to use for teachers and 3) to prepare pedagogically qualitative resource. So, the technical and methodological criteria for resource have to be defined (Figure 2).

Figure 2: The criteria of interactive visualization

There are two groups for criteria: for dynamic drawing and for Interactive image. Dynamic drawing is a construction of geometric objects which is changing, when some points are moved or parameters are changed. Interactive image is the whole
image with dynamic drawing, formulas, steps, descriptions and et. The dynamic drawing is a part of interactive image. These criteria help to construct pedagogically and technologically qualitative resources.

The competencies of two different domains are required to create qualitative learning resource. The competence of mathematics educations lets to review mathematics curricula and select topics for visualization. The technological sophistication lets to introduce facilities of technology (in this case dynamic geometry) and to prepare templates for scenarios. The creation of scenarios requires pedagogical and mathematical knowledge. Then the scenario has to be realized in some application (dynamic geometry, Java ant et.). The artefact of some learning scenario is got after realization. This artefact (the authors call it learning resource) have to be tested by the author of scenario and improved some corrections if it requires.

This process of an interactive visualisation is shown as the method using the dynamic geometry (Figure 3).

Figure 3: Method of the interactive geometry visualization using dynamic geometry

Method has three main stages:

- The learning scenario stage. The relation between Learning Object types and Teaching Methods are important for organizing learning process – to predict learning scenario where the interactive visualization will be used.
- The curricula stage. The study of National mathematics secondary school curricula let authors to distinguish class for scripts of templates which can help to prepare digital learning tools for geometry. Templates make easier to prepare scripts for programmers.
- The interactive image stage. The script has to be realized in some application (dynamic geometry, Java ant et.). The artefact of some script is got after realization.

The experiment of realised method
The set of interactive images with the dynamic geometry is prepared by the presented method and the influence of them to student's geometric skills is ascertained by the experiment (Jasute, Dagiene, 2012b). The questions for the experiment are as follow:

1. If the interactive images created by the above method and used for geometry teaching, have any effects for students' geometric skills?
2. What changes the interactive images have for students' geometric skills?
3. What abilities are improved when interactive images are used for teaching-learning?
Two teaching and learning methods for the measure of the experimental factors (independent variables) are used in the experiment: 1) the interactive geometry images are used for the individual learning in the computer class (for experimental group E1) and 2) the interactive images are used to visualize teacher’s explanation (for experimental group E2).

The study has used a pre-test and post-test for measurement. The results of pre-test and post-test of each group have been compared. Also the growth of average score of each group has been compared with other groups: the group E1 average growth has been compared with average growth in control group (group C), the group E1 average growth has been compared with average growth in group E2, and the group E2 average growth has been compared with average growth in group C. The obtained results of experiment were processed using the statistical package SPSS and descriptive statistics. The model of experiment is shown in Figure 4.

The results of experiment show that (Jasute, Dagiene, 2012b):
1. Interactive geometry images improve student’s geometry skills. But for group when interactive images have been used for demonstration the improvement has been significant.
2. However it does not help the students to improve their skills significantly when they learn geometry individually using interactive images in this experiment.
3. Traditional methods also improve students’ geometry skills in the experiment. The importance of teachers’ role in the lessons can be discussed here.
4. The experimental results shows that the drawing skills are improved when used interactive images.
5. The most skills are improved when these interactive images with dynamic geometry are used for demonstration of the teacher’s explanation. However the skill to understand the mathematics text and the skill to identify and to apply properties of geometric objects to solve problems are not improved in the experimental group with the significant mean growth.
6. The demonstration of the interactive images is effective method for teaching mathematics. The analyzing pre-created sketches also improves students’ abilities, but it is not significant in this experiment.
7. Authors still recommend to use pre-created sketches for the teaching and learning mathematics of the students in the secondary school. The experiment shows that most effective results may be attained when the traditional methods are combined with new one in our schools initially.

CONCLUSION

We provide the first extensive analysis of the problem field of interactive (dynamic) visualisation in geometric contests of secondary education (to our knowledge). A novel idea has been suggested and investigated to visualize geometric contest of secondary education consistently using dynamic geometry principle. There is engineering solution (method) for visualization of secondary school geometry domain presented.

The pedagogical experiment was provided to prove influence of pre-created interactive images for student’s skills. The interactive images were created by the method of interactive visualization. The results of experiment show that student’s skills were improved significantly in one experiment group. And in other group the improvement was not significant. The experiment let authors to answer to their questions, but there arise new ones which need additional experiments.

The next step of the research is to evaluate method by using Multiple Criteria Decision Analysis and expert evaluation.

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Biography

Egle Jasute works at the Vilnius Jesuit gymnasium from 1997 till now. She is a teacher of mathematics and informatics. She is PhD student at Vilnius University Institute of Mathematics and Informatics. E. Jasute assists in localization of software for schools; uses those and others software in her lessons at school; wrote some papers and books about use of software; made two educational CD for mathematics: “Mathematics 9 with Geometer’s Sketchpad” and “Mathematics 10 with Geometer’s Sketchpad” with join authors. She reads courses for teachers about usage of the Informatics Technologies in mathematic.

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