Learning Method for Development
of Discovering and Creativity
# of Pupils and Students in Basic Education

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Abstract—The common problem of the current primary and secondary education in the Czech Republic is the lack of interest of pupils and students on technical and science education. The interest on technics and science has to be stimulated from children's age during primary school education and strengthen during secondary school education. Pupils and students should discover and create. The paper focuses the method of "Creation and Discovery via Computer". The method is based on implementation of modeling and simulation to education in primary and secondary school education. The method of Creation and Discovery via Computer can be understand as appropriate tools for development of ability of the pupils and students to solve the problem, discover and create.
The paper presents two case studies showing the possibilities of implementation of method of Creation and Discovery via Computer to secondary and primary learning.

Keywords—Primary education, secondary education, educational frameworks, creativity, discovering, modeling, simulation.

I. INTRODUCTION

Basic education in the Czech Republic consist from primary education and secondary education. The education of both levels is managed by educational frameworks - Educational Framework for primary schools [1] and Educational Framework for secondary schools [2]. Both educational framework defines key competencies of the education e.g. competence for learning, competence for solving the problems, communicative competence, social and personal competence, civic competence, working competence. On the other hand, common problem of the current primary and secondary education in the Czech Republic is the lack of interest of pupils and students on technical and science education. It is presumably caused by the fact, that educational frameworks does not define key competencies for creation and discovering.

Both Department of Informatics and Department of Technic of the University of Hradec Kralove start to develop the method of "Creation and Discovery via Computer" as one of the possible of learning method for strengthening of pupil's and student's interest on technics and science.

The paper presents two case studies based on this method.

II. THEORETICAL BACKGROUND

A. Basic Education

Basic education builds on family's education, preschool education and school education. Basic education is the only the stage of education in the Czech Republic, that all pupils have to graduate. Basic education is in the Czech Republic divided to primary education and secondary education [1]. During basic education, pupils and students gradually acquire such personal qualities that allow them to continue their studies at high schools, to innovate in the future professions and actively participate in society.

1) Characteristic of Primary School Education

Primary education in its conception helps transition of pupils from early family and childhood education to compulsory, regular and systematic education. It is based on learning, respecting and developing individual needs, capabilities and interests of each pupil. Primary education by its activity and practical character, using appropriate methods motivate pupils to continuing learning, lead them to the learning activity and to the recognition that it is possible to search, discover, create and find suitable ways of solving problems [1].

The creative and stimulating environment is required at primary school education. The pupils have to be stimulated. It is important to bright pupils, encourage the less talented pupils, protect and support the weakest pupils. The attention has to be also focused to talented pupils and the talent of these pupil has to be developed. The primary education ensures that every child through learning develops optimally in accordance with him own assumptions for learning. Atmosphere in the primary classrooms should be friendly and welcoming. The

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learning in the primary schools has to encourage pupils to study, work and provide them by activities that suit their interests, space and time for active learning and full development of their personality [1, 3 and 4]. Educational Framework for primary schools [1] defines six key competencies:

- competence for learning,
- competence for solving the problems,
- communicative competence,
- social and personal competence,
- civic competence,
- working competence.

2) Characteristic of Secondary School Education

Secondary education is in the Czech Republic divided in the amount different specializations. Commonly, the secondary education has to create challenging and motivating learning environment in which students have opportunities acquire a specified level of their key competencies, i.e. learn some important knowledge, skills, attitudes and values. Students has to be able to use above mentioned in personal, civic and professional life. The purpose of secondary school education is not only gain the broad facts and data, but also provide the students with systematic and well-structured knowledge, teach them to incorporate the information into a meaningful context of everyday practice and motivate them to reach new knowledge and developed their skills [2]. The students should learn procedures and methods that support their creative thinking. The students should be able to solve the everyday life problems. The secondary learning has to developed student's creativity in all areas of the learning. Educational Framework for Secondary Schools [2] defines six key competencies:

- competence for learning,
- competence for solving the problems,
- communicative competence,
- social and personal competence,
- civic competence,
- competence of entrepreneurship.

B. Creation and Discovering

Currently, the common problem in the Czech Republic is **lack of interest of primary school pupils as well as secondary school students on technical and science education**. The technical as well as creative thinking and skills of pupils and students is insufficient.

The situation has to be changed by complex development of personality of children and adolescents from primary school education up to secondary school education.

Pupils as well as students should **create and discover**. Pupils / students should feel success from their creativity and discovering, they shouldn't be afraid of failure.

The **competence for creation and discovering** should be developed in both primary and secondary school education in the Czech Republic. There are different method how to develop this competency. One of the possible solution is

presented in the National curriculum of primary education in UK [5, 6].

C. Computing at Primary Schools

Based on this curriculum, the development of creativity and discovering of the pupils (and obviously students) can be reached by high-quality computing education. It equips pupils / students to use computational thinking and creativity to understand and change the world. Computing has deep links with mathematics, science design and technology, and provides insights into both natural and artificial systems [5, 6]. The attention is also focused to computer science (the modern discipline much used by pupils / students). The pupils / students have to understand the principles of information and computational technology, how digital systems work, and how to put this knowledge to use through programming. Pupils / students are equipped to use information technology:

- to create programs – it developed their creativity;
- to model systems – it developed their discovering.
- to create simulation program – it developed their creativity as well as their discovering.

The method of computing has been implemented in UK from the 2014 to the National curriculum of primary education in UK [5, 6]. Based on this curriculum pupils should be able to:

- Apply modeling to discover fundamental principles and concepts and analyze problem;
- Analyze problems in computational terms;
- Write computer programs in order to solve the problems;
- Evaluate and apply information technology, including new or unfamiliar technologies;
- Analytically solve problems.

Above mentioned principles can be extended and are valid even for secondary education.

Computing can be currently understood as one of the method in education, namely in context of modeling and computer simulation.

D. Modeling and Simulation in Education

Scientific modeling and computer simulation are the terms which are closely related.

Modeling and computer simulation play important role not only in the science but also in pedagogy. Using the method of modeling and computer simulation helps pupils / students formulate problems, understand the principles of the problems and solve the problems.

From the education point of view the modeling and simulation can be applied [7, 8]:

- In the field of sciences - in case of models and simulations of science processes and phenomena;
- In the technical fields - in case of the process control of machines and simple robots;

- In the humanities and social studies - in case of the processes and phenomena associated with this issue;
- In management - in case of the management processes and quality control processes.

The process of modeling and simulation could play important role not only in development in pupil's / student's discovering, developing of their creativity but also in developing of their computational, algorithmic and logical thinking. It is related to the fact that simulation models are represented by executable computer program that has to be designed (**development of creativity**) based on the algorithmic rules (**development of thinking and discovering**) – see e.g. [9, 10, 11].

Positive influence of modeling and simulation to development of discovering and creativity of high school students and has been already confirmed in many researches – see e.g. [12, 13].

Similar researches has been recently realized in Department of Informatics, Faculty of Science, Univerzity of Hradec Kralove. The results of the research also confirm that modeling and simulation develop student algorithmic and logical thinking as well as creativity – see e.g. [8, 14].

Regarding the fact, that complex development of personality starts in children's age (see e.g. [15, 16]) it is important to start with development of competency for creation and discovering in primary stage of the education and continue with this development in secondary school education.

The paper presented possibilities of development of competence for creation and discovering in the primary and secondary schools in the Czech Republic in three below mentioned case studies.

III. RESEARCH

A. Implementation of the Method of Modeling and Simulation for Development of Competency for Creation and Discovering

The principle development of competency for creation and discovering is implementation of method of modeling and simulation to education in primary and secondary schools in the Czech Republic. We called the method as

"**Creation and Discovery via Computer**" (**CDC method**).

The method is based on implementation of modeling and computer simulation across the subjects in the curriculum of primary and secondary education (e.g. mathematics, languages, natural sciences, etc.). We understand the method of CDC as appropriate tools for development of ability to solve the problem, discover and create. We expect the CDC method will help develop whole pupil's and student's personality. The CDC method:

- Strengthen computational learning in primary and secondary education;
- Introduce mathematical modeling and computer

simulation to primary and secondary education;
- Strengthen interdisciplinary learning at the boundary of computer science and other disciplines in primary and secondary education.

The method of modeling and simulation can understood as appropriate method of learning in primary and secondary education.

B. Case Study 1 – Computer Simulation Example for Secondary School

Creation of computer simulation is closely related to process of modeling. Before the students create simulation program they have to realize the mathematical model of studied phenomenon or process has to be designed. Computer simulation is process of executing the mathematical model and it e enables representation and visualization and of the model. These are fact and rules that students of the secondary school should realized.

A typical simulation model can be written either through specialized simulation applications or in standard programming languages. The example of computer simulation presented in this case study is realized in MS Excel Worksheets and visualization in MS Excel Chart. Using of MS Excel as tool for creation of simulation program developed not only creativity of the secondary school student but also their computational thinking.

The MS Excel enable visualized not only static systems but also dynamic visualization based on iterative recalculation of cells. Creation of dynamic charts visualization is popular between secondary school students. Other advantage of MS Excel is that the Integrated development environment in form of Visual Basic for application, which enable creation of rather difficult simulations. Detailed information on dynamic visualization and programming in MS Excel can be found e.g. in [17].

The case study presented in this paper is task that students have to pass in their final test in subject physics, part mechanics. The test assignment is as follows:

"Create computer simulation program in MS Excel Spreadsheet for calculation of the breaking distance and breaking time of the car. The constants are the gravity acceleration ($g = 10$ m/s^2). The input variables are the reaction time of the driver (t_R) and the dwell time of the brakes (t_D), velocity of the car (v_0) and coefficient of friction (f). The numeric output are total breaking distance (s_B) and total breaking time (t_B). Graphical visualization should represent time dependency of the decreased velocity $v(t)$. The visualization should be created in MS Excel Chart."

The students has to find mathematical model of the solution based on mechanics rules.

The following equitations are valid:

$$t_B = t_R + t_D + \frac{v_0}{gf} \tag{1}$$

$$s_B = v_0(t_R + t_D) + \frac{1}{2}\frac{v_0^2}{gf} \tag{2}$$

$$\begin{aligned}
v(t) &= v_0, & t &\in \langle 0, t_R + t_D \rangle \\
v(t) &= v_0 - gft, & t &\in \langle t_R + t_D; t_B \rangle \\
v(t) &= 0, & t &\in \langle t_B; \infty \rangle
\end{aligned} \tag{3}$$

The equations (1) and (2) provide numeric result for calculation of total breaking time and total breaking distance. The simulation and graphical visualization of the time dependency of velocity $v(t)$ can be created based on equation (3).

One of the student's solution in form of MS Excel Chart is show on the Figure 1.
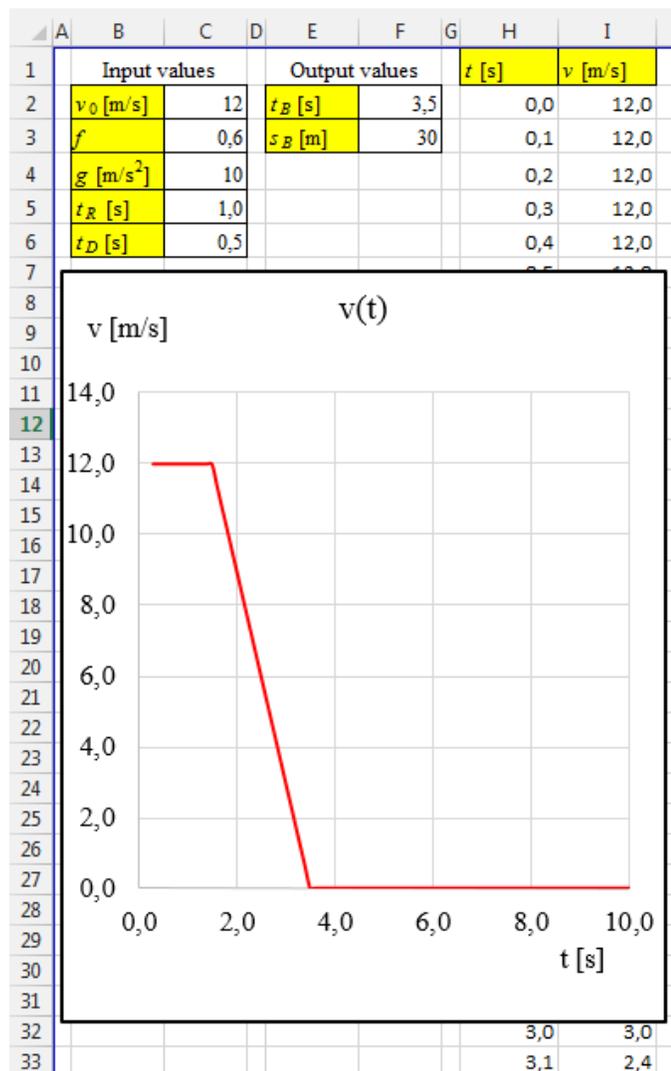
Fig. 1   Example of student's solution of simulation task.

C. *Case Study 2 –*
     Computer Simulation Example for Primary School

While creation of simulation model and visualization of the phenomena and processes via computer can be required from students of secondary school, pupils of the primary school should discover. The discovering via computers should help develop pupil's interest on science and technics.

The pupils in their age are not able to create simulation programs. They can use simulation's programs for development of their discovering (particularly the younger pupils up to 10 years). The older pupils (from 10 years) shift their discovering to creation via computer and they are able to create simple simulations and visualizations by themselves. For creation of such simulations they have to use simple author systems.

There are amount of author systems that:

- allows create simulations suitable for pupils in primary learning;
- allows create simple simulations directly by pupils.

The primary school creation's materials presented in this case study is created in Hot Potatoes author system.

The creation's materials and exercises can be designed in Hot Potatoes author system directly by teacher or by older pupils. Creation of such material in Hot Potatoes represents major shift toward the use of method CDC to primary school education in the Czech Republic.

Figure 2 shows example of integrated development environment of Hot Potatoes author system and Figure 3 shows the example of final screen of learning material.

The presented example was created by 14 years old pupil and is used as learning material in the third class of the primary school (9 years old pupils).
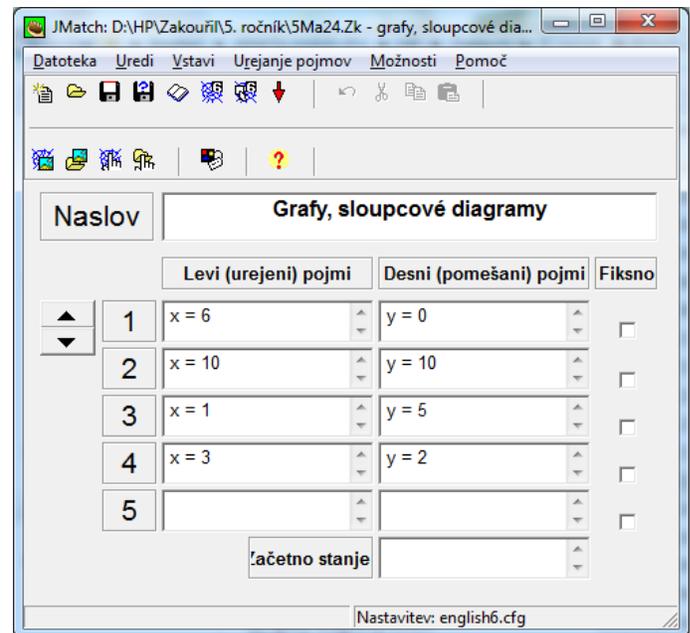

Fig. 2   Integrated development environment of the Hot Potatoes author system.
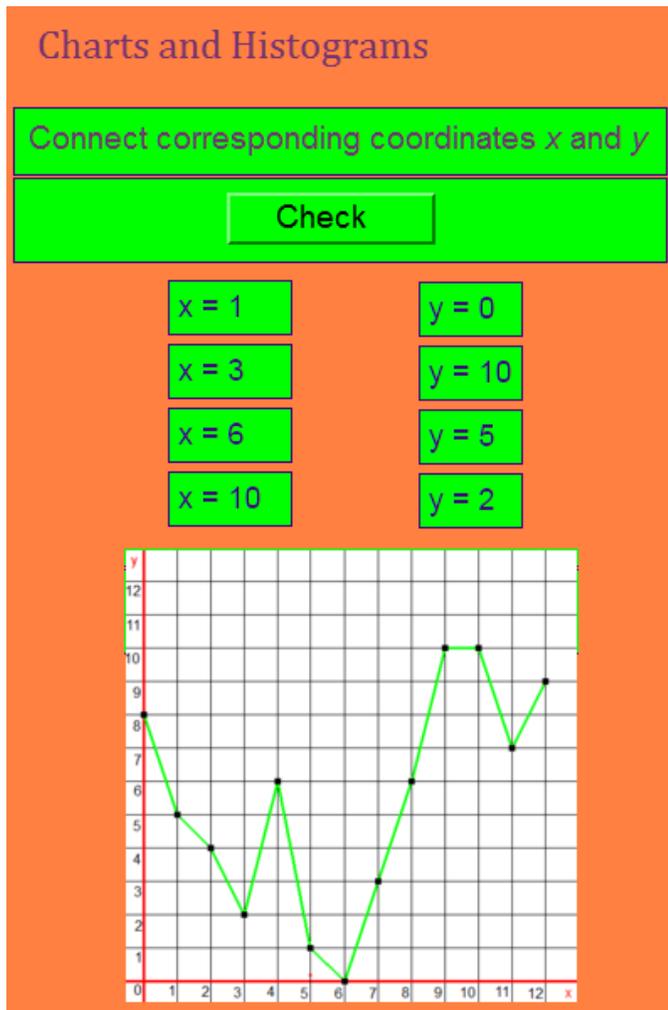
Fig. 3   Example of the final screen of Hot Potatoes learning material

IV. Conclusion

The paper presents the method of "Creation and Discovery via Computer" as one of the possible method for development of interest of pupils and students on technical and science education. The method of CDC is based on implementation information and communication technologies, modeling and simulation to learning of primary and secondary school. Two case studies presented in the paper demonstrate possible examples of using of the CDC method in secondary and primary education. Statistical research confirming the effectiveness of CDC learning in the primary and secondary schools education will be realized in Czech primary and secondary schools in 2016 and 2017.

Acknowledgment

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