

## Project teaching in mathematics

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### Introduction

Projects (mainly interdisciplinary) were used in the teaching of mathematics in the Czech Republic quite a lot in 1930' and were rediscovered after a long pause in 1990' due to an educational reform.

This method, as it is perceived today, started up in the USA at the beginning of the 20<sup>th</sup> century. The turn of the 19<sup>th</sup> and 20<sup>th</sup> century brought the criticism of "traditional school" that opened the space for using alternative methods of teaching, including project teaching. Among founders of this method belong especially John Dewey and William Kilpatrick. They emphasized that it was a child who should be in the centre of teaching, not curriculum. Dewey promoted school which brings a child into situations that are adequate for his/her age and experience. His motto was "learning by doing" (Dewey, 1919). The thoughts of John Dewey were put in practice by William Kilpatrick. He emphasised the importance of a child's interest and proposed to concentrate on learning with projects (Coufalova, 2006).

There is no uniform definition of the term project. Many authors do not define it at all and different authors grasp it differently. E.g., Petty (1996) understands a project as a task or series of tasks, which are solved by pupils individually or in groups. Pupils can often decide how, where, when and in which sequence they will deal with the tasks. Grecmanova and Urbanovska (1997) show that Kilpatrick specifies a project as every systematic and independent activity during which we solve different tasks. Also several Czech authors, such as Manak, Vrana, Kubinova and others work with terms project and project work.

My understanding of a project corresponds to that of M. Kubinova (2002) who points out the following requirements which a project should fulfil:

- a) It is a part of curriculum and leads to a specific goal.
- b) It is not constructed as a fixed programme but it is developed and realised on the basis of pupils' responsibility.
- c) It is related to out of school reality and it arises from pupils' experience.
- d) It brings concrete results for pupils (it can be of a material or mental nature – a model of a house, or a formula, etc.).

### Constructivist approaches to the teaching of mathematics

In my opinion, a project, its construction and teaching through projects are closely connected to constructivism. I agree with Davis, Maher & Noddings (1990, p. 2) that "learning mathematics requires construction, not passive reception, and to know mathematics requires constructive work with mathematical objects in a mathematical community".

Constructivism is primarily a theory of learning, not teaching. I believe that "even our understanding of the potential implications of constructivism for the classroom, is our *personal construct*" (Stehlikova, 2007). There have been many attempts to apply the principles of constructivism in teaching mathematics (e.g., Jaworski, 1994, see Confrey & Kazak, 2006, for a survey of literature). In the Czech mathematics education, principles of so called *didactic constructivism* have been formulated (Hejny & Kurina, 2001, shortened):

1. Mathematics is understood as a specific human activity, not only as a result of the activity.

2. An important component of a mathematical activity is searching for relationships, solving problems, creating concepts, etc.
3. Knowledge is not transferable. It is constructed in our minds.
4. Construction of knowledge arises from experience.
5. A motivational context is the basis for educational process.
6. Interaction among pupils and pupils and the teacher contributes to the development of knowledge construction.
7. It is very important to use different representations and structured development of mathematical word.
8. Communication and cultivation of different mathematical languages are highly important.
9. The educational process should be evaluated from three standpoints: understanding mathematics, gaining skills, application of mathematics.
10. Knowledge based on reproduction leads to mechanical understanding.

Some of the goals of project teaching such as solving problems, searching for information, gaining different skills, etc., correspond with the principles above.

In my work, I concentrate on projects constructed under these principles.

### **Illustrations of projects**

Here are two examples of projects that I have prepared and used in my teaching.

1) TRIANGLES – the project was prepared by a teacher for 6<sup>th</sup> graders (12 year old pupils) and was carried out at school during 2 subsequent lessons of mathematics. The main mathematical aim was to summarize pupils' knowledge about triangles. Among non-mathematical aims belonged the development of competencies such as cooperation with other pupils, learning strategies (pupils learnt how and why to use a concept map for their studies), and a personal development. Pupils worked in groups and their task was to produce a concept map (a map of ideas) about triangles (one map for each group). Before they started their work, rules for work and criteria for evaluation were set up.

At the very beginning of the project we worked with cut-outs (models) of triangles to recall as many terms connected to triangles as possible. Then I showed pupils what a concept map was (I used a word “dog” and we created together a simple concept map). Afterwards pupils were divided into groups and they started to work on their own concept maps. In the end, pupils presented their work in groups. The groups talked about the mathematical part as well as about the process of their work on the poster. Pupils also evaluated their work on the map of ideas, group work and summarized the pros and cons of these two lessons. They were stimulated by the following questions:

1. What were the main principles of creation of a concept map?
2. How could we use a concept map at school / out of school?
3. How did you like working in groups?

While I was evaluating this project, I asked myself questions related to the criteria of evaluation that were mentioned above plus the following ones:

1. Which phenomena appeared in their concept maps? Which of them were the most frequent ones?
2. Did pupils focus on the knowledge gained during previous lessons or did they bring something new?
3. How did pupils work? Were they interested in the work?

2) SMALL TRAVELLERS – the project was also prepared for 6<sup>th</sup> graders (12 years old pupils) and carried out within two weeks at school (3 lessons of mathematics, 1 lesson of information technology) and outside the school. Pupils could work in groups of maximally three people or alone and they produced a poster. The aims of this particular project were to revise unit conversions, rounding decimal numbers, calculating average values; the development of competencies such as cooperating with other pupils and responsibility for one's work; effective searching for information by using the Internet and other sources. Before pupils' own work, rules for work, criteria for evaluation and the deadline were set up. In the first lesson of mathematics pupils received a worksheet containing a motivational task plus three more tasks (questions) that should be fulfilled. In the subsequent lesson of information technology they could search for necessary information. The same day pupils compiled gained information and in one week they presented their posters in the classroom.

In the first task pupils received the description of the route between two towns (a map and an itinerary) and they solved several sub-tasks based on it concerning unit conversions, rounding decimal numbers, calculating average values etc. The three following questions asked them to find out: a) the variant of transport connection with the lowest cost, b) the fastest variant of transport connection, c) recommend one of the variants to other travelers and give the reasons for their choice.

### **My research**

As stated above, projects are being increasingly used in Czech schools; however, as far as I know, their impact on pupils' learning in mathematics has not been studied yet (with the exception of Kubinova's work). In my work I plan to focus on the following questions: *What are the advantages and disadvantages of project teaching as opposed to traditional teaching? How do mathematical concepts evolve in pupils' mind when working on projects? Which mathematical topics are appropriate for project teaching? Which aspects of projects are motivational for pupils? What is the appropriate use of projects in mathematics lessons (that is, the use which aims to get good results in pupils' understanding in mathematics, joy from it, motivation towards it, etc. and is reliable in everyday teaching)?*

I am in my second year of study. So far I have collected some data concerning projects (descriptions of projects in my teaching and the teaching of others) and I am still in the process of specifying my methodology. At the moment I a) am working on a survey of literature on research on the use of projects in mathematics abroad, b) plan to carry out a pre-experiment (prepare a project, carry it out in a school while collecting data through video recording, audio recording, artefacts of pupils' work, my field notes, some interviews with pupils, and analyse the data using a grounded theory based approach), c) have to narrow and specify my research questions according to the results of pre-experiment. I also consider another possibility of aiming my research, namely to a) determine about 5-8 characteristics of project teaching generally attributed to it by literature (e.g., project teaching develops pupils' ability to self-regulate their learning, develops their ability to cooperate in groups, helps to overcome isolation of school subjects), b) follow in the class of 16 pupils how these expectations are met.

I do hope that discussions at the summer school will further my search for an appropriate methodology, more specifically, the research question(s) and the appropriate method(s) of data collection (e.g., how to collect data for the whole class or shall the project be organised in a smaller group? shall I follow the progress of some particular students during the year?). I would also appreciate if I learned about any research carried out on project teaching.

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