

**Theses of PhD Dissertation**

**EFFECTS OF AN EXPERIMENTAL TEACHING  
METHOD ON SCIENTIFIC CONCEPT  
DEVELOPMENT, PROBLEMSOLVING AND  
OTHER PSYCHOLOGICAL FACTORS**

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Supervisor: Dr. habil. László Tóth  
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Doctoral School of Human Sciences

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## **1. Introduction, aims of the studies**

By the 21<sup>st</sup> century social background and requirements have changed very much. We can meet these circumstances in primary and secondary schools as well. The aim of public education is to evoke and develop certain skills, competence and abilities which will be able to help the growing up generations live full life in a knowledge-based society.

However several national and international studies have proved that though our students have appropriate scientific knowledge, they cannot apply them in a suitable way.

We have to devote more time and energy how to teach primary school pupils scientific concepts including requirements and teaching methods.

That is the reason for choosing the topic of this essay, which was to study the effects of the applied so-called Rostock Model, as an experimental teaching method, on scientific concept development, scientific problem solving, school motivation, creativity and environmentally friendly attitude.

It could be laid down as a fact that looking for the possible positive effects of the applied teaching method our study concerns three important fields, which are the following:

1. close look at the cognitive development owing to the positive effects of the applied method especially regarding concept development and use of problem-solving strategies,
2. exploring correlation between the applied method and psychological backgrounds such as school motivation and creativity,
3. analysing development of environmental conscious attitude.

### *The Rostock Model*

The Rostock Model is an international cooperation, which has been on since 2004. Its primary goal is to improve applying and understanding scientific concepts and environmental awareness. It puts emphasis both on social characteristics of learning and understanding, interactive learning. In addition to this it takes personal needs of pupils and aspects of motivation into consideration. The following features are supposed to be the most crucial in the procedure of learning: 1.) discussing phenomena, 2.) introducing of those in words or in drawings by the pupils, 3.) in the cause of improving cognitive skills dealing with general interdisciplinary topics such as „Water“, 4.) putting emphasis on the goals of learning, 5.)

pupils have to be aware what they know at what level, 6.) explaining natural and environmental phenomena, 7.) independent learning by following instructions, 8.) improving communicative skills, 9.) importance of feedback and self-evaluation, 10.) effects of different curriculums and culture of countries on scientific thinking and environmental awareness.

Among the most important goals of Rostock Model there is improving problem solving and metacognitive skills in the procedure of learning by applying groupwork and individual work in lesson. In this process showing and explaining experiments has a crucial role.

## **2. Applied methods and materials**

In the second part of the dissertation two cross-section studies are presented. The studied samples were the same concerning the experimental group, while in the case of the control group it can not be said. That is why we did not investigate development. All of the pupils were taught from the same textbooks according to the national curriculum.

The studied sample involved 8-12 years old pupils from four primary schools (two from Debrecen, one from Budapest, one from Rostock). Experimental teaching was always done in spring, while testing came in autumn. Our study took three years and collecting data was scheduled in two different time.

The first part of the study took place in September 2006, in which 292 pupils (98 experimental and 194 control) took part from class 2.

In the second part of the study 238 pupils, from class 4 (72 experimental and 166 control) were involved in September 2008.

In order to carry out the surveys, first we had to construct the sequence of problem tasks involving the topic of cleaning water and circle of water, taking science requirements of class 2 and 4 into consideration. We had to analyse problem-solving tasks appeared in the post-test written by the experimental group and the books and workbooks used by the control group.

Following to this, among pupils class 4 we analysed school motivation and creativity in order to get more insight in the correlations of these psychological aspects and the effects of the applied teaching method. Furthermore we studied the effect of the applied method and environmental education on pupils' environmental awareness by compiling a questionnaire.

Then beyond studying some aspects of cognitive development we analysed psychological backgrounds such as school motivation (with questionnaire by Kozéki-Enstwitle), creativity (with Circle-test by Torrance) and environmental attitude (with questionnaire by ourselves).

### **3. Results and Discussion**

We grouped the results in four hypotheses relating to cognitive development within it concept development of the studied population:

- 1) In the first hypothesis we intended to detect fewer items out of ten in class 4 than in class 2 as they learnt the concept of water circulation in class 2 that's why we have to take forgetting into consideration, too. After analysing our results we could state that items of the concept of water circulation do not follow one another consistently, some of them are missing from time to time, so development of the concept is mosaic-like, in class 4 several items do not appear as part of the long-lived knowledge. For the future we could suppose that too long and complex concepts such as water circulation should not be involved in the requirements of primary schools as there is little chance for pupils to understand, learn and use them regularly.
- 2) Searching approving of the second hypothesis we studied the ten-item long concept in each group. As we supposed that pupils from the experimental group could follow the concept more efficiently than the pupils from the control group. This hypothesis was confirmed especially in class 2 where only two items appeared in more than 20% among the answers of the control group, while four items (rising of temperature, evaporation, cloud, rain) emerged in more than 40% among the answers of the experimental group. In class 4 one third of the control pupils and two third of the experimental pupils know that evaporation happens owing to rising temperature. Concerning the whole concept there is not such a big difference between the two studied groups, so the positive effects of the applied teaching method could be detected in the year when both groups learnt the concept according to the curriculum.
- 3) In the third hypothesis we expected a so called microstructure of the concept which includes the most important items of the concepts which are crucial for the pupils to be

able to understand and learn the given scientific concept. As we have already mentioned four items such as rising of temperature, evaporation, cloud, rain seemed to appear in the answers of each group so these must be the root of the concept.

- 4) In the fourth hypothesis we assumed that due to the applied teaching method concept development could be faster among experimental the pupils. We supposed that more experimental pupils would use scientific concepts instead of every-day concepts than control pupils would. In the answers it was interesting to see that every-day words seemed to appear as explanation of scientific concepts which indicates meaningful learning. In this case scientific concepts do have meaning for pupils. However, among the experimental pupils there are some who use only the scientific concept of evaporation, so the improving effect of the applied method is really convincing in their case. Although some control pupils in class 4 started to use only scientific concepts but the difference between the two groups still remained. Yet there is one more question concerning the future: will this difference be an advantage for the experimental pupils?

We grouped the results in five hypotheses relating to cognitive development within it the use of problem-solving strategies of the studied population:

- 1.) The justification of the first hypothesis of this survey related to use of problem-solving strategies analysing the number and the proportion of the strategies helped us. We supposed that the experimental pupils used more problem-solving strategies than the members of the control group. Our results showed that in class 2 experimental pupils used more problem-solving strategies on a larger scale than the control group did. The achievement of the control group was great in the steps of forming hypothesis and partial planning, while the experimental group's achievement was between 32-51% from steps partial planning to evaluation. In this field the results of the control group in class 4 seemed to be very similar to those of class 2, while the members of the experimental group made great progress in step of forming hypothesis. When we added the applied steps of problem-solving the two studied groups'

achievements were turned out to be contradictory. The results expressed in percentage are high in zero and step one in the control group, among the members of the experimental group there is hardly anybody who has not used any steps of problem-solving, furthermore they mainly used one or two steps of it.

- 2.) Our second hypothesis supposed that the applied teaching method would have a positive effect on problem-solving and this difference would remain till class 4. Contrary to all expectation we did not manage to detect such a great difference which can be explained by the natural cognitive development of the control group.
- 3.) In the third hypothesis we assumed that among the experimental pupils in class 2 there would be some whose cognitive development got into the formal stage. According to our results though in each group there are pupils with the skill of abstraction the proportion is greater in the control group (0.48) than in the experimental one (0.33).
- 4.) The fourth hypothesis concerned the positive effects of the applied teaching method on cognitive development in class 4. The average achievement of the experimental group (0.78) surpasses that of the control group (0.33). The subject of further survey could be analysing the backgrounds of this great difference.
- 5.) We failed to justify the fifth hypothesis relating to the correlation between concept development and the efficiency of using problem-solving strategies. Public education has to meet constantly changing social requirements where the quality and quantity of the knowledge system can change but skills of problem-solving have to be improved all the time. The results of the survey suggest that we cannot develop problem-solving without dealing with teaching scientific concepts.

Hypotheses related to the description of certain aspects and correlations of psychological backgrounds such as school motivation are the following:

- 1) We assumed that in our survey cognitive sub-scale represents the lowest level from the dimensions of school motivation regarding the motivation for gaining knowledge at school. We used the average points of descriptive statistics and the one-modelled trial for defining the significance of deviations as an aid to prove this. Our assumption was proved, which is a problem because we expected this dimension and the sub – scales within it (independence, competence, interest) to have the closest coherence with problem solving. This fact seems to underline the former results, according to which Hungarian students do not have a suitable desire for knowledge, and interest concerning knowledge gained at school. However, if we would like to improve public education in quality, increasing the numbers of motivated and interested students are one of the conditions of it.
- 2) In the second hypothesis concerning school motivation we supposed that the dimension of affiliation (needs of being with others and accepted by others) would not be so significant in the studied groups because of their age. At the same time the dimension of identification (needs of being accepted by the teachers) would be more crucial for the given group. Our results suggest that among the dimensions of school motivation emotional warmth and taken care seem to be the most important among the pupils aged 10-12.
- 3.) We assumed that the dimension of being interested, needs of being together with the others would take a distinguished place among the dimensions of school motivation in the experimental group as they had worked in pairs and groups several times during the experiment. Unfortunately, such a kind of effect of the applied teaching method could not be detected. One of the possible explanations can be that to achieve such an effect we should have applied the method longer extended to most of the subjects.
- 4.) In the fourth hypothesis strong correlation between the cognitive dimensions and the state of development of use of problem-solving strategies. According to our results we did not manage to find such a kind of correlation, so further studies are needed.
- 5.) We succeeded in justifying the fifth hypothesis as school motivation does not seem to affect concept development.

Hypotheses related to the description of certain aspects and correlations of psychological backgrounds such as creativity are the following:

- a. In the first hypothesis we supposed that the most creative pupils' achievements would be at a higher level in use of problem solving strategies as a result of the applied method. This hypothesis were proved by the studied three basic indexes of creativity as there is a significant difference among the creativity of the pupils used one , two or three problem-solving strategies. Even our research draws attention to the ability of problem solving cannot be improved without taking improving creativity into consideration.
- b. In the second hypothesis we assumed creativity as an influential factor has a determinant correlation with the ability of problem-solving. It was proved as those pupils who managed to reach the level of planning and evaluation in problem-solving had higher indexes in creativity which make us think that fluency, originality and flexibility of our thinking influence the state of development of problem-solving positively. However the creativity indexes of those pupils who could reach the level of partial planning in problem-solving are not higher necessarily those of who failed to do anything to be measurable. As far as the experimental group considered we failed to detect such a positive correlation. In their case the most creative pupils do not reach the final steps of problem-solving. This apparent contradiction can be explained mainly by the chosen problem-solving task since during the experimental teaching these pupils could see, make and interpret several experiments related to cleaning dirty water so our problem-solving task did not seem to be a challenge for these pupils rather they were bored with it.
- c. In the third hypothesis we did not expect any correlation between creativity and concept development. Our results justified it as with the sub – programme of SPSS programme variance analysis we failed to detect any significant difference.

Hypotheses related to the description of certain aspects and correlations of psychological backgrounds such as environmental attitude are the following:

- 1.) In the first hypothesis we assumed that certain sub-topics would be more preferred than others. Our presupposition was proved as the topics of protection plants and animals, saving water and energy were found to be more preferred than waste management. At the same time news about the environment does not seem to be interested by the pupils.
- 2.) In the second hypothesis we supposed that the environmental attitude of the studied groups would be above the average due to the applied method and the 10-year long environmental education took place in schools. According to the results it could be stated that environmental attitude of both groups is above the average (72,8% - control group, 78,5 - experimental group) which let us hope that the next growing-up generation must be more environmentally aware.
- 3.) In the third hypothesis we expected that there would be a difference between the environmental attitude of the two groups depending on which school they attend since schools cannot build the content and methods of environmental education into their teaching-learning process. The location of the school seems to have an effect on pupils' environmental attitude as we detected 74% average environmental attitude in Debrecen, while in Budapest it was 66%. Studying the effects of the teaching method we can state that there is a significant 17% difference between the two groups in Budapest which can be explained by the effect of the teaching method and the result of the environmental education of the last 10 years.

Our research and results could be a starting point for further scientific investigations relating to Rostock Model as our study involved only some possible aspects which seemed to be worth studying at the very beginning. For the future we can state that it sounds wise to find out the applied method what extent influences attitude of pupils towards science.

To sum up, it can be stated that the success of teaching-learning process is influenced by several factors. One of the most important is that what extent the given institution can build up-to-date methodology into its practice and improve pupils' skills and abilities by meeting the requirements of our society. When a new method is applied like the Rostock Model this process can be helped.

#### 4. Publications on the topics discussed in the dissertation

##### Papers:

- « **Revák-Markóczi, I., Tóth-Kosztin, B., Tóth, Z., Dobó-Tarai, É., Schneider, I. K., Oberlander, F.** (2008): Effects of the „Rostock Model” on metacognitive development of pupils. *Journal of Science Education*, **9**(2), 94-99.
- « **Tóth-Kosztin, B.** (2009): Environmental awareness at primary level. *Acta Universitatis Sapientiae*, **1**. 177-184.
- « **Tóthné Kosztin Beáta** (2010): A „vízkörforgás” fogalom fejlődésének vizsgálata általános iskolás tanulók körében. *Magyar Pedagógia*, 2. sz. 167-180.
- « **Tóthné Kosztin Beáta** (2010): A problémamegoldás hatékonyságának vizsgálata 2. és 4. osztályos általános iskolás tanulók körében. *Alkalmazott Pszichológia - közlésre benyújtva*
- « **Tóth-Kosztin, B., Revák-Markóczi, I.** (2008): Environmental Science, Concepts and Cognitive Development at Primary Level. *Acta Pericemonologica Debrecina*, **3**. 32-39.
- « **Tóthné Kosztin Beáta** (2010): A problémamegoldó készség vizsgálata általános iskolások körében. In: Balogh László - Koncz István - Mező Ferenc (Szerk.)(2010): *Pszichológiai metszetek. Professzorok az Európai Magyarorszáért*, Budapest, 9-14.
- « **Tóthné Kosztin Beáta** (2010): A környezettudatos attitűd vizsgálata általános iskolás tanulók körében. In: Balogh László - Koncz István - Mező Ferenc (Szerk.)(2010): *Pszichológiai metszetek. Professzorok az Európai Magyarorszáért*, Budapest, 20-24.
- « **Revákné Markóczi Ibolya -Tóthné Kosztin Beáta -Tóth Tibor** (2003): Kísérlet a természettudományos problémamegoldás fejlesztésére a középiskolai biológiatanításban. In: *III. Országos Neveléstudományi Konferencia, Program tartalmi összefoglalók*, Magyar Tudományos Akadémia Pedagógiai Bizottság, Budapest, 2002. 115.
- « **Tóthné Kosztin Beáta – Revákné Markóczi Ibolya**: Környezettudomány, fogalmak és kognitív fejlődés- általános iskola és annak vetületei a tanárképzésben. *IV. Kárpát-medencei Környezettudományi Konferencia*, Debrecen, 2008.I kötet 49-55
- « **Tóthné Kosztin Beáta - Revákné Markóczi Ibolya** (2008): Kisiskolások természettudományos fogalmi gondolkodásának fejlesztési lehetőségei. AGTEDU Magyar Tudomány Ünnepe Konferencia, Kecskemét, 2008.november, Konferenciakiadvány, 216-222.
- « **Tóthné Kosztin Beáta** (2010): A problémamegoldó képesség vizsgálata általános iskolások körében. *VI. Kárpát-medencei Környezettudományi Konferencia*, Nyíregyháza, 2010. 577-583.

### Lectures:

- « **Revákné Markóczi Ibolya -Tóthné Kosztin Beáta-Tóth Tibor** (2003): Kísérlet a természettudományos problémamegoldás fejlesztésére a középiskolai biológiatanításban. *III. Országos Neveléstudományi Konferencia*, Budapest, 2003. október 9-11.
- « **Tóthné Kosztin Beáta - Revákné Markóczi Ibolya** (2008): Kisiskolások természettudományos fogalmi gondolkodásának fejlesztési lehetőségei. *AGTEDU Magyar Tudomány Ünnepe Konferencia*, Kecskemét, 2008. november 6.
- « **Revákné Markóczi Ibolya -Tóthné Kosztin Beáta** (2009): A problémamegoldó stratégia használat vizsgálata általános iskolában. *Országos Neveléstudományi Konferencia*, Veszprém, 2009. november 19-21.
- « **Ibolya Revák-Markóczi, Beáta Tóth-Kosztin** (2007): Rostock Model in education of sustainable development. *5th International JTET Conference*, Debrecen, 2007. május 30-június 2.
- « **Ibolya Markóczi-Revák, Beáta Kosztin-Tóth, Iona K. Schneider, Franz Oberlander** (2009): Improvement of Skills for Sustainable Development in the Primary School. *7th International JTEFS/BBCC Conference*, Daugavpils, Latvia, May 5-8, 2009.
- « **Tóthné Kosztin Beáta – Revákné Markóczi Ibolya**: Környezettudomány, fogalmak és kognitív fejlődés- általános iskola és annak vetületei a tanárképzésben. *IV. Kárpát-medencei Környezettudományi Konferencia*, Debrecen, 2008. március 28-29.
- « **Tóthné Kosztin Beáta** (2009): A környezettudatos attitűd vizsgálata általános iskolás tanulók körében. *V. Kárpát-medencei Környezettudományi Konferencia*, Kolozsvár, 2009. március 26-29.

### Posters:

- « **Ibolya Markóczi Revák - Tibor Tóth - Beáta Kosztin** (2000): The development of problem solving and its relationship with other influential factors. Talent for The New Millennium. *7th European Council for High Ability Held in Debrecen (Hungary)*. August 19-22, 2000. Papers Submitted to the Conference, Debrecen, 2000.
- « **Beáta Kosztin Tóth – Ibolya Markóczi Revák** (2009): Study on environmental awareness at primary level. *7th International JTEFS/BBCC Conference*, Daugavpils, Daugavpils, Latvia, May 5-8, 2009.
- « **Tóthné Kosztin Beáta** (2010): A problémamegoldó képesség vizsgálata általános iskolások körében. *VI. Kárpát-medencei Környezettudományi Konferencia*, Nyíregyháza, 2010. április 22-24.