LEGO and LOGO in the primary school – a simple way for learning through creation

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Abstract

The introduction of "IT" in primary school acquaints the children with the possibilities of the contemporary computer systems and the variety of their applications. It provides the acquisition of basic knowledge and practical skills of working with computer which gives the children the opportunity to use computers for accomplishing their own ideas and projects.

For that purpose the IT education should provide:

- facilities accessible, understandable and attractive to the child;
- ensuring great variety of activities and permanently active role of the child in the learning process;
- the opportunity to work on topics and issues of interest to the child itself and being directly related to its actual life experience;
- the creation of a particular product that is valuable from the child's point of view and is able to "materialize" the invested skills and efforts.

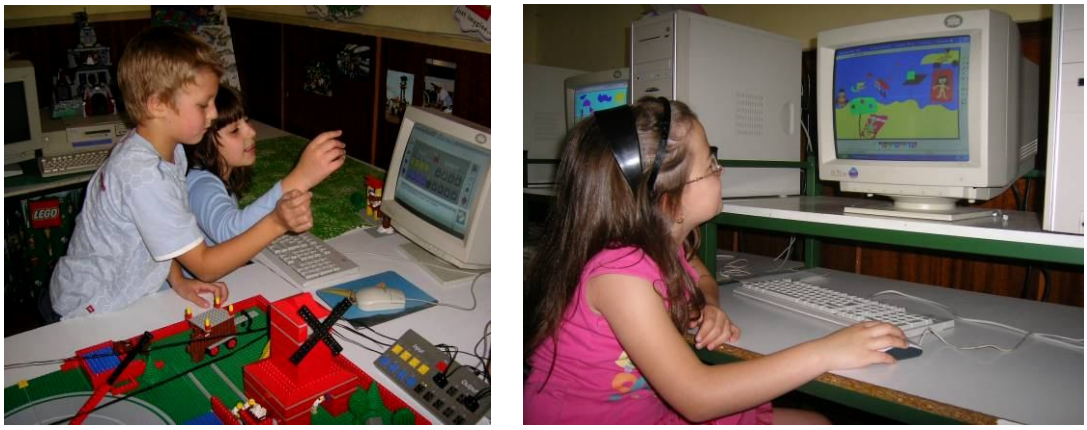

Figure 1. LEGO and IT activities

In that context this paper deals with the inclusion of LEGO in the educational program in order to enrich the teaching of IT with new meanings and as an instrument of providing a larger variety of activities in the teaching process. Using the computer as a tool for managing and control of external objects (in this case LEGO models, created by the children themselves) reveals one more remarkable area of its application. That is also a natural motive of introducing the children to programming in a way attractive, interesting and accessible for them. The result of programming is very attractive and devoid of abstraction. It is easy to formulate as a prior expectation and clear to describe step by step, as it concerns behaviour that the child knows from the real life.

Keywords

Primary school, IT education, LEGO, LOGO, programming

Introduction

In Bulgaria, a non-mandatory national curriculum for learning to work with computers in primary schools was implemented in August 1998. It was introduced as a “free elective subject.” The curriculum, in 11 modules, was written by us and had been developed within our school over the previous year (Illieva and Ivanov 1999). Its main goal was to use the capabilities of the computer as a powerful new medium to challenge children in the context of normal activities for their age. This goal is attained by a project-oriented approach that we consider fundamental to the process of education. Children implement their ideas in projects that are based on personal experience and important events in their lives. Each project leads to the accomplishment of different types of activities, which are drawn from the school curriculum. In this way the children accept an active and creative role. This is why one module was “Working with computer systems for the control of models.” It was based on my work with children and LEGO-LOGO in the primary school over the previous six years. This and other modules were optional for technical and financial reasons.

In 2006 learning to work with computers became an “obligatory elective subject” in primary school. This subject was given the name “Information Technology.” National standards were set and a new curriculum was written by a team of which we were members. Both can be found on the Ministry of Education website, http://mon.bg.

The first curriculum remains an option for primary schools as a free elective subject. So, LEGO-LOGO, which was not included the new curriculum, is still possible.

The primary school is the specific element of the system of education where the child acquires initial knowledge and skills in a diversity of areas. At the same time the child also develops basic and enduring habits, concepts and attitudes to everything studied, to the teaching itself (including the place, the people and the approach related to it) and the learning as a process of individual intellectual activity. In this sense the primary school is a fruitful territory for any kind of novelties because they are perceived spontaneously and positively by a population free of fears and prejudice. It is at the same time a dangerous territory from the point of view that this is exactly a time when bad habits and attitudes can very easily be formed and reinforced.

The introduction of new technologies in the primary school provides many opportunities; and their application can serve the achievement of various objectives. The new technologies can influence both the educational environment in its complexity and any particular process of leaning and teaching. This is regardless of whether they are introduced as an independent subject of study, or used in a specific manner within other subjects of the curriculum.

Therefore regardless of the early age, new technologies should be presented in the full diversity of their multi-functionality. By this means the child may obtain a general overall, rather than deeper but disjointed, concept of the possibilities offered by the computer as a technical means. The child will become acquainted with most of the many applications that they may later use.

Considering the specific nature of the age-group – it is demanding for any such project to provide for:

- facilities accessible, understandable and attractive to the child;
- a great variety of activities with a permanently active role for the child in the learning process;
- the opportunity to work on topics and issues of interest to the child him or herself, which are directly related to their actual life experience;
- the creation of a particular product that is valuable from the child's point of view, and that is able to "materialize" the invested skills and efforts.

IT and LEGO activities

Ever since the creation of LOGO as a programming language and a pedagogical concept, numerous and varied LOGO-based microworlds have been developed and used worldwide. The purpose of each microworld was different. They were designed to organize specific pedagogical situations where the child acts and learns by using the tools and options of the microworld. In the proceedings of the Eurologo conferences since 1987 many such microworlds are documented.

To support the curriculum and provide teachers with materials that worked well with children we created a LOGO-based software package, “Tool Kid”, containing 48 small programs/microworlds divided into 7 groups, specially designed to introduce working with the computer to young children. With their help children are learning to handle the mouse and the keyboard. They investigate the properties of the computer and use the tools necessary for the treatment of various types of information – graphics, text, sound, animation and video, individually and in combination. Development took several years including rigorous school trials (Illieva and Ivanov 2001, Ivanov and Ilieva 2005). Tool Kid was published, with teacher and student books (Illieva and Ivanov 2003-2006, Ilieva and Ivanov 2004-2007). It is used by all primary schools that teach IT.

In the information technology classes I now teach, I use the microworlds in Tool Kid too☺. The key principle laid down in the creation of these programs is that in any of them the child should have appropriate environment, tools and options to act and learn, using them to solve a case or create a particular end product. The product can vary – it may be just a puzzle to solve or a picture to color, but it may be also a personal graphic project, a story, comic, multimedia card, slide show, film. The important thing in any such case is that the product is created by the child personally. She or he has to apply, in the process of creation, the knowledge and skills acquired; to improve them; and even acquire new ones.

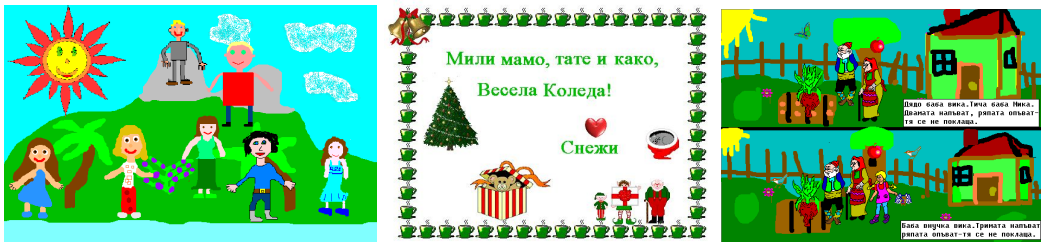

Figure 2. Examples of children’s work in IT lessons

When acquired knowledge or skill can immediately be used in practice towards the achievement of a particular goal, one which is personally important, this generates interest. From this comes motivation to acquire more and more knowledge and skills; and put conscious, voluntary effort to this effect. This turns the child from an object of education into an active participant/subject in the process.

LEGO

If LOGO is a high-performance programming environment that has enabled us – the adults, to create a wide range of microworlds dedicated to one or other specific purpose and where children can learn by acting, LEGO is also a high-performance material environment, but one in which the children themselves create their own microworlds. Again it is of the greatest importance in this situation that they learn through action.

Working with LEGO constructional materials the children come to know the surrounding world by recreating it. The elaboration of any model places the child in a situation of very dynamic activity.

This is not merely the activity of manipulating elements and building a structure. The situation encourages the child to remember, examine, juxtapose and analyze the object in depth both as a whole and in its details; to seek and find the relations and interactions between parts; to realize functions, purposes and dependencies. The active action is not merely a complement - it is born and needed by the highly intellectual activity, and the great emotional attachment of the child to what they are doing.

LEGO and IT

In this context I have been using LEGO in my classes as a part of teaching about and with the new technologies. It initiates the children into the world of programming by showing them how to use the computer to control and operate the functioning of external objects.

The fact that these objects are actually the models they have created is almost guarantees the children's personal commitment to the activity. Basic principles are being learned in the course of the practical activity of model operation and control. Complicated explanations are avoided.

Both construction and programming require and develop the following skills:

- imagining the whole;
- analyzing details;
- forecasting consequences;
- realizing correlations;
- following sequences;
- seeking precise expression;
- seeking options

The result of programming is very attractive and devoid of abstraction. It is easy to formulate as a prior expectation and clear to describe step by step, as it concerns behavior that the child knows from the real life. The errors are quite flagrant and the disappointment – quite strong.

The emotional involvement of the child in the model emerging in the course of its creation is transferred to programming which appears in this case as the final stage of the construction event. This is a strong motivation to maximum concentration, to seek options, for error identification and troubleshooting.

Organization of the work

For twenty years I have taught LEGO and IT in primary school. I began this work in an experimental school and continued it in a private school. Both schools made it possible for what I wanted to do to be a full part of the school curriculum. So, in my present school, all pupils from 1st for 4th grade take two class hours of information technology and two class hours of LEGO construction weekly. To conduct the classes the school equipped a computer room with workstation for each pupil and a LEGO room with enough construction material to enable the common and simultaneous work of all the children in a class.

In the IT classes the children acquire basic knowledge and skills of working with computer systems and information technologies by creating their own products during their work on various projects.

In the LEGO classes they also become familiar with the structural material, the specific properties of each element and its possibilities, by gradually starting to create models. As models become more and more complicated there is a switch from individual to team work.

Like teaching computer skills, LEGO teaching breaks down construction into necessary skills. These are learned, applied, and refined through all four primary classes.

The integration of both subjects starts at the end of the second and the beginning of the third year. The knowledge and skills acquired in the information technology and English language classes, the latter being studied since the first year, find their application in the implementation and programming of their first controllable prototypes. This continues to the end of the fourth year. The prototypes become more complex in structure and function. The greater diversity also poses more challenging programming tasks.

Inserting this course to the regular curriculum and providing the necessary technical support to conduct it has enabled all the children to participate on equal terms. They all participate in a continuous and consistent training evenly spread over the entire four-year span of the primary school. This makes it possible to establish continuity between and relations among the year groups.

Themes and models

In her/his work the teacher is often facing a situation when she/he has to act as mediator between the new educational ideas, technologies, means and materials, and the child – the end user for whom they are intended. The teacher reduces the overall idea to a sequence of specific steps and actions in order to make possible its practical realization. S/he negotiates the interaction between the idea and the child to whom it is intended. In construction this is carried out through the topics on which the children work and the prototypes they are creating.

In my work with controllable prototypes I use the LEGO Data Control Lab. For the primary school age group this system provides me all the necessary devices and tools to work with the children in a wholesome way. The only problem is that the published technical schemes of models are not intended for primary school kids and therefore they are not appropriate for them. The models are too complex as structures, the objects to recreate are vague in terms of "behavior", and insufficiently attractive as ideas since children are very unlikely to meet them in their everyday life.

Therefore in thinking over the prototypes I bear in mind two things: a) the complexity of the structure into which the computer-controlled element is going to be integrated, and b) the complexity of the guidelines to be followed for its implementation.

Thus, I choose models that:

- Can be implemented by the children as a construction task with their available skills and materials;
- Naturally presume the presence of controllable devices – motors, lamps, sound elements, sensors;
- Will be attractive in both appearance and "behavior";
- Recreate objects familiar and interesting to the children;
- Recreate "behavior" that could be met in real life, and that is simple and clear enough to be described and then programmed.

The task is never reduced to the mere elaboration of an isolated controllable model. It should be an element of a situation reproducing as closely and realistically as possible the object's natural environment and its functioning within it.

The design of situations is more motivating, more challenging and more creative than the mere creation of a isolated prototype. It is richer in correlations, interactions and dependencies which should be sought, identified and recreated deliberately; which implies better cognition. The situation around the controllable model and its interlacing with other surrounding objects as it is in real life makes its "behavior" more authentic. The behavior is more understandable as it is somehow dependent on its ambiance and interacts with it. This helps the children to see more clearly the algorithm of functioning of the model and comprehend its purpose. In turn, this gives

more sense to programming and reduces the degree of its abstraction. Moreover the modeling of situations is conducive to the organization of team-work. The objects are numerous but they are all elements of a large comprehensive project. Every child participates actively in creation, making his/her individual contribution. Another advantage is that there could be more than one controllable object which makes programming richer, more sophisticated and more open to variation.

Projects

Street lighting

I use street lighting first, to teach the elements of the operation and control system including: computer, interface block, model with integrated control device, and cables for the connections in between. The purpose and functions of each of these elements is explained.

The modes of cable connection to the different devices and the test port functions are shown. The operating algorithm, main interface of the operating program, introducing the control commands and their execution in direct mode of operation are demonstrated.

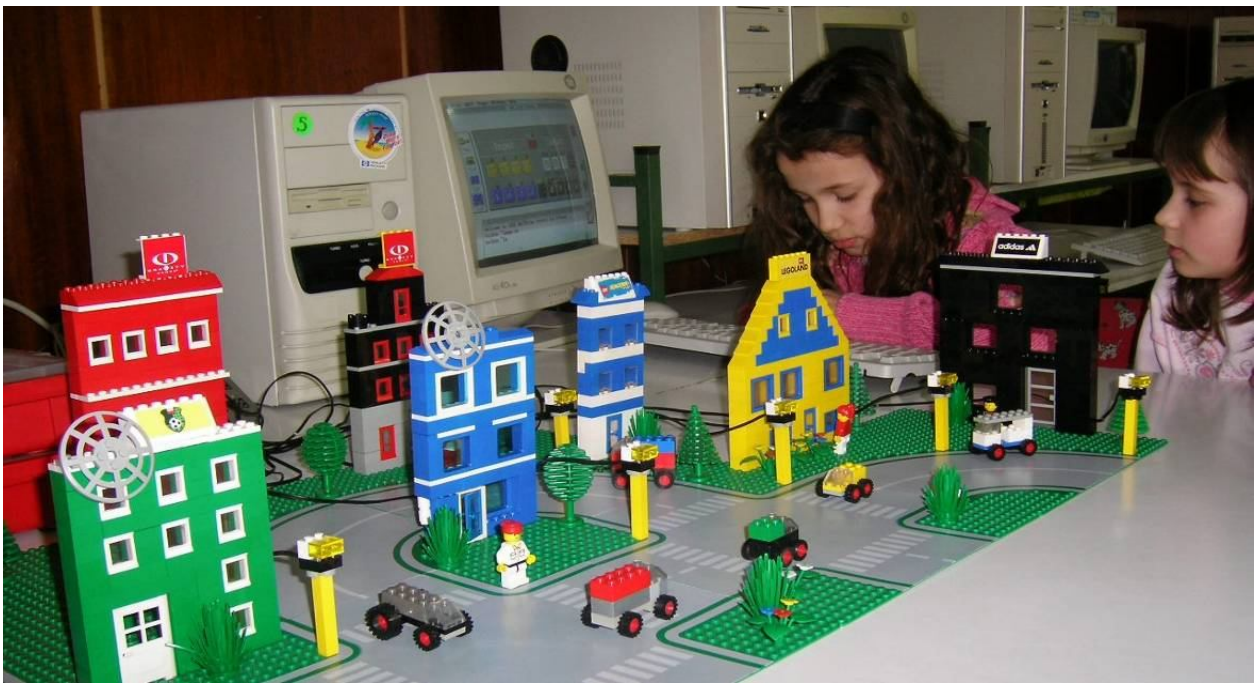

Figure 3. Staring to program their street lights using LEGO DACTA Control Lab Logo

Children's own experience – they have all seen the street lights and know that the lamps are switched on every evening and switched off in the morning and they are aware that this is being operated centrally and not by employees walking about in the streets to make this manually. The project includes the construction of a city with streets and street lamps placed along them.

Controllable devices – lamps.

Commands – *talk to*, *on*, *off*, *wait*, *repeat*.

The work on this project is continued into the third year, by including use of light sensor in order to associate the lamp operation to a particular condition. This entails the natural necessity to introduce the *waituntil* command. The work is no longer in direct but procedure mode.

Traffic light

The project incorporates the elaboration of a small village with one main street with a pedestrian crossing with a traffic light on it. One side of the street is bordered by the houses. On the other side are – the shop, the post office, the restaurant and the school. The traffic light is necessary to help people reach the place they live, work and amuse themselves without risk of accidents.

Figure 4. Building the street, and connecting and programming the traffic lights

The connection of the devices, the operating program opening and the service check are being performed without help from the teacher.

Children's own experience – they know the traffic rules, they have observed how the traffic lights work day and night, they can describe the algorithm of operation and associate it to their own behavior as pedestrians. Analysis of the traffic light operation in night mode – blinking orange light.

Refreshing the commands of the previous session, their meaning and the consequences of their execution.

Controllable devices – lamps.

Commands – Work in direct mode where the children try their own various hypotheses about the sequence of commands to put the traffic light in proper operation. The traffic light is in continuous daytime mode of operation. Introduction of the *onfor* and *forever* command.

A similar project is being worked on in the third year, this time in the city with traffic light for pedestrians and cars at a crossroad. It includes the use of *sound* element as a sound signal to the traffic light, intended for people with visual impairments. This makes it possible to associate the operation of a device, i.e. a lamp with another device, i.e. a sound element. In this situation it is necessary to think about not only the programming solution but also the scheme of connecting the devices to the interface block. The project can be further developed by including a light sensor and linking the traffic light functioning to a condition, according to which it is switched from daytime to night mode and vice versa, as was done with the street lamps.

The work is organized in procedure mode. The idea of a main procedure with sub-procedures is introduced. The fourth-year project work is focused on a crossroad with functioning traffic light and vehicles following the traffic rules: to move ahead when the light turns green. The vehicle operation programs include the use of touch sensor enabling the kids to operate them.

Windmills

Introducing a new controllable device – the motor.

Functions – to drive the windmill propellers.

Learning how the motor is incorporated within the windmill prototype structure. The project includes the construction of their own windmill by every child – before that a conversation is held on its purpose, appearance, functioning.

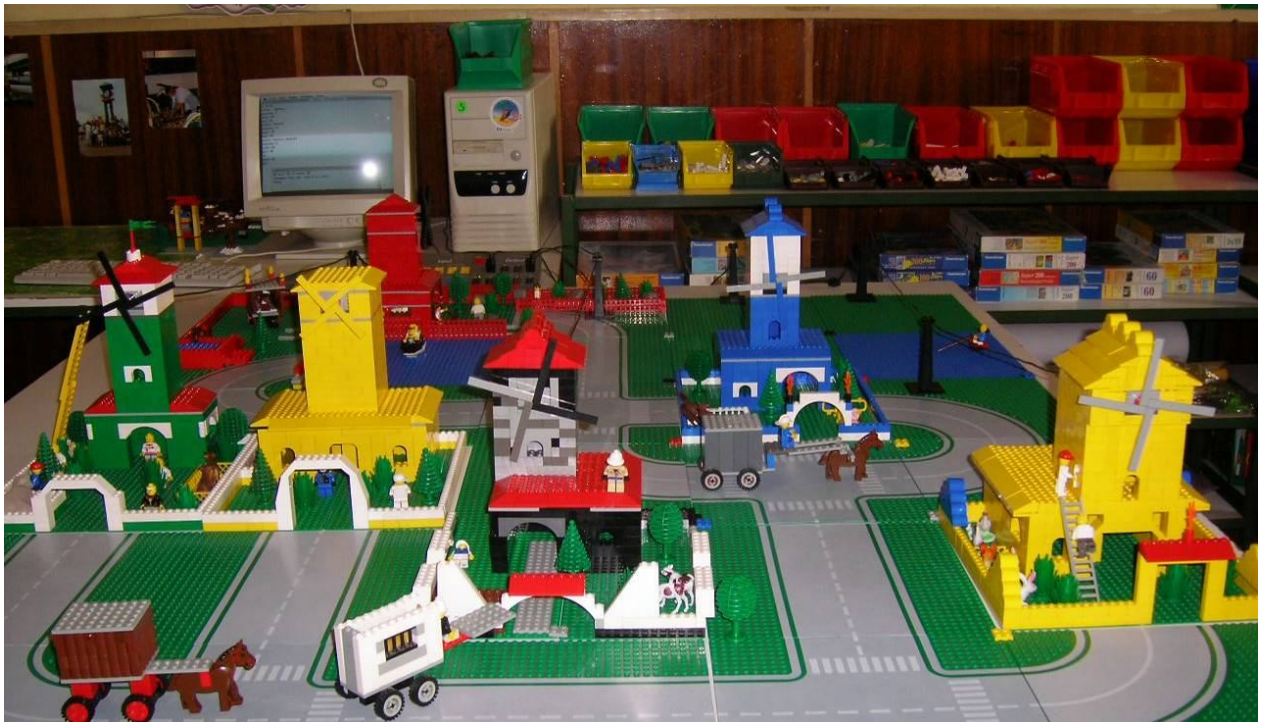

Figure 5. The windmills

The children's own experience – they have seen working windmills and know what they are used for. A situation including the participation of people and animals should be recreated around each windmill model.

Model operation – working in direct mode. Introducing the *rd* command for the direction of rotation of the axis driven by the motor. Every child creates their own program to operate their windmill. A condition is set for the windmills to work on different algorithm. All the patterns form an integral model through connecting pathways and landscape designed around them. This project is worked on in the third year. The *setpower* command is introduced.

Operation – the work goes into procedure mode. Every child first creates a procedure to operate its own windmill and thereafter creates one main procedure to bind together the functioning of all other mills in a common sequence. The "behavioral" idea of the models is suggested by the children.

Discotheque

A group project the purpose of which is to make a model of discotheque with air conditioning and programmed lighting.

The children's own experience – they know how a discotheque looks like, what do people do there, they have observed the light effects and are aware of the presence of air conditioning system and its purpose.

Introducing a new device – temperature sensor and associating it to the operation of the fans. The lights programming here requires maximum attractiveness and diversity. The *forever* command is introduced.

Figure 5. Ventilator control procedure for the sensor and motors, at the back of the discotheque

Operation – working in procedure mode. Separate small procedures are created for the various types of light effects operated by one main procedure. The main procedure also includes the fan control procedure. A project entitled "Circus" can be developed as a version of this project.

Police Action

This project is being worked on in the fourth school grade. It is intended to recreate a story with a plot. The situational model includes a street with several houses and a police station. One of the houses is equipped with alarm system. A light sensor is installed in the anteroom against the front door. There are signal lamps installed in the police building. A prototype of police car is made, which embodies an engine and siren. Another car prototype with an engine is made for the thieves.

The task is to make a program so that the thieves' car starts first and stops in front of the house front door. While the front door is open, the light sensor detects increased lighting. This causes a blinking signal light to go on in the police station. Five seconds after it starts blinking the police car should set off with siren sounding and stop right in front of the house.

Procedure mode is used with main procedure and sub-procedures. The class is divided into teams of 2-3 children: The team constructing the house is in charge of programming the sensor control; and the team designing the police service is in charge of the signal lamp programming etc.

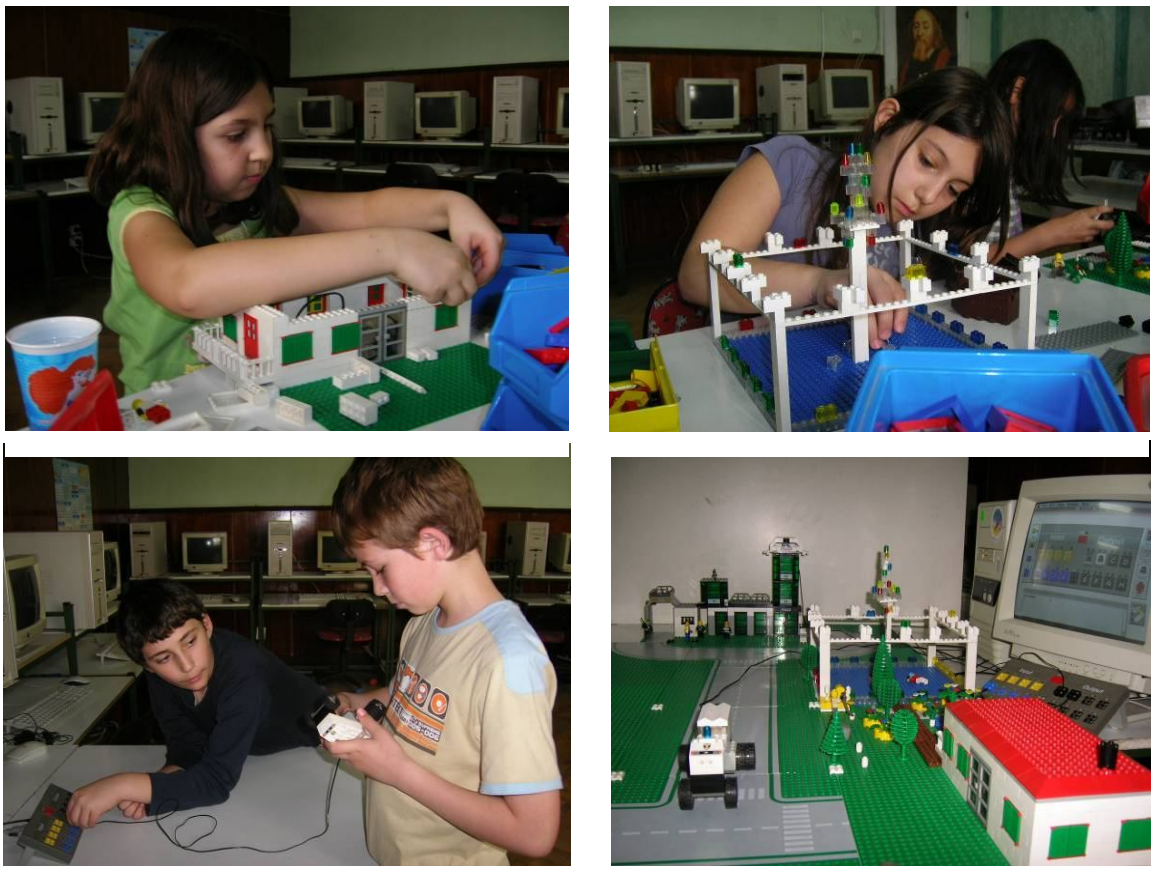

Figure 6. Police – Action!

Christmas Town and Amusement Park

These are collective projects with the participation of all the children from 1st to 4th grade. The first is made before the Christmas holidays and the second – for the school year end.

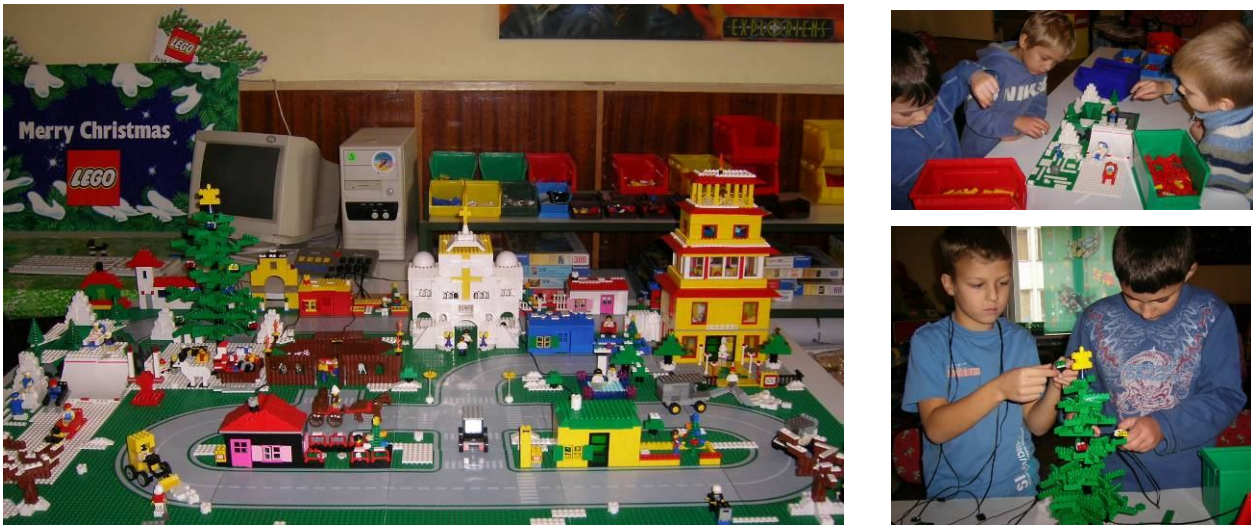

Figure 7. Christmas town, with programmed lights on the tree and in the houses

The model is large and every class takes part in it by implementing some part of the common subject. The 4th grade pupils are in charge of the programming.

Figure 8. 4th grade watching their program work – and a close-up of another ride

In summary

Organizing the IT education as a work on personal projects, which leads to the creation of an end product with a personal meaning to the child, provides a different context in applying knowledge and skills; and guarantees the child's personal activity during that education.

The teamwork during these class hours and the group projects of the class in the IT and LEGO lessons is very important for the children themselves and the school life in general. Many ideas are generated in the teamwork, the communication is dynamic, the disputes which arise cultivate the ability to find arguments, to compromise. This environment is beneficial to multifaceted and diversified reasoning, to the formation of ability to take independent decisions and bear the consequences of it. The traditional teaching quite rarely provides natural opportunities and necessity to work in a team.

Regardless of the fact that I have discussed these school sessions mainly within the context of the IT classes I believe that they are influencing in a specific way the entire development of the children, the school environment and the pupils' attitude towards studying and education.

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