MAGIC BLOCKS TO TRIGGER CREATIVE, MATHEMATICAL, LOGICAL, LANGUAGE, STRATEGIC AND SOCIAL SKILLS IN PRE-SCHOOL AND PRIMARY SCHOOL CHILDREN

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Abstract

Autonomous learning is a basic life-skill of critical importance for young learners’ future development. The EU project Block Magic aims at introducing a new teaching methodology and technology targeting children between the ages of 2.5 and 7 who are attending pre-school or the early years of primary school. The overarching goal is to help the acquisition of life skills. Through the use of technologically enhanced attribute blocks, a wide variety of competences will be stimulated, such as creative, mathematical, logical, language, strategic and social skills – all these skills are important for lifelong learning. This paper presents the Block Magic methodology and gives examples of learning activities especially designed for the different target skills.

Keywords: Block Magic, pedagogy, attribute blocks, logical blocks, technologically enhanced, RFID sensors, acquisition of skills, creative skills, mathematical skills, logical skills, language skills, strategic skills, social skills, children, pre-school, primary school.

1 INTRODUCTION

It is generally recognised that ICT can make a useful contribution to learning in infant and primary schools. However, many techniques require major investments in equipment, skills and time. The EU project Block Magic1 proposes a novel, ICT based teaching methodology, especially suited to situations where these resources are unavailable.

Many learning activities for young children involve manipulation of physical objects. However these techniques work best when teachers dedicate their attention to a single child or one small group of children. Block Magic approach allows multiple groups to work simultaneously. Furthermore, Block Magic allows the creation of personalized learning activities and supports novel techniques of learning.

Block Magic is centered on the concept of a magic block – an “intelligent” version of the “logical blocks” and “teaching tiles” already familiar to teachers. The traditional logical blocks (sometimes referred to as “attribute blocks”) were invented by Z.P. Dienes2. It is a structured material composed of 48 pieces organized in 4 categories: a) color, (red, yellow, blue); shape (square, circle, triangle, rectangle); thickness, (thick, thin) and size (small, big).

In block Magic when children touch a block, or a sequence of blocks with a wand or a glove, the system generates feedback (e.g. by talking) that changes from one activity to the next or at different stages in the same activity. This feature makes the system an endless source of surprise and curiosity. In a typical scenario, the class is divided into groups and provided with few bags of Magic Blocks. The teacher sets a task (e.g. find the missing piece) designed to develop a specific creative, logical, linguistic, or strategic skill. The children then work together to solve the task.

This article focuses on the learning activities designed by Block Magic for triggering the acquisition of specific skills. Following, we present the Block Magic teaching kit designed within the project. Further, we discuss the skills targeted in the selected child group (i.e. ages of 2.5 and 7). We provide an example of a learning activity designed and discuss the relation with the targeted skills. Finally, we make notes on the important for the design axes confirmed during the preliminary evaluation that has been performed in May 2012.

1 Block Magic (LLP project No. 517936-LLP-1-2011-1-IT-COMENIUS-CMP), www.blockmagic.eu
2 http://www.zoltandienes.com/?page_id=2
2 THE BLOCK MAGIC TEACHING KIT

The Block Magic teaching kit consists of a set of magic blocks, a magic device, a specific software and a teacher’s manual specifying learning activities. In other words, Block Magic Training Kit is a small suitcase containing all materials needed by a teacher to put in practice the Block Magic concept and exercises with children.

![Figure 1: the Block Magic Teaching Kit](image)

Block Magic combines a set of 48 blocks, each one different from the others. Block are of four different geometric shapes (square, triangle, circle and rectangle), three colors (red, blue and yellow), two thicknesses (thick and thin) and two sizes (small and big). The traditional set of these blocks is known as “attribute blocks” or “logic blocks”. The Block Magic system combines the traditional tiles with a low-cost RFID technology (Radio-frequency identification), a passive RFID sensor for automatic identification of the blocks, a wireless RFID reader device (called the wand or the magic wand) which reads the blocks identifiers and communicates them back to the software, an “intelligent” software (a “Finite State Machine”) build ad-hoc which receives input from the wand and generates an “action” and which is able to personalize the formative path of the learner based on usage data collected during exercises, and a usage manual which specifies learning activities and educational scenarios to be used by the teachers.

The goal of Block Magic is to introduce a new teaching methodology and technology targeting young children between the ages of 2.5 and 7 who are attending pre-school or the early years of primary school. Nowadays, often teachers deal with big groups of children in the same class (e.g. 20-25 children). In previous studies such teachers have told the Block Magic research team that they often conduct learning activities in small groups, moving from group to group to observe learner progress. Thus, in current practice, teachers often focus on one group of children at a time, while leaving the others without supervision. Block Magic can help ensure that all the children in a class can participate at the same time and will receive timely and frequent feedback on their activities. The team hypothesized that the new technology would allow children to work in groups autonomously, contributing to learners’ social skills, strengthening their ability to learn autonomously, and prospects for later stages in their education.

The Block Magic software is of the type “intelligent” software, i.e. it is able to adjust the training based on the learner’s responses. It can offer a customized to the learner training using a probabilistic algorithm, i.e. the system will be able to propose in each game session a set of exercises of varying difficulty and focusing on different skills. The degree of difficulty and the type of targeted skills, will be determined on the basis of the results obtained from playing in the previous session. To choose the right exercises, the algorithm will use a decision system based on a Gaussian curve. Thus, the major portion of the exercises will fall within the competence of the child, while a smaller percentage will be represented by exercises outside of these skills, so as to ensure a set of variables such as, for example the degree of learning of the different skills, the degree of interest, the learning curve, etc. The basic assumption is that every child learns in a very peculiar and subjective way, depending on the different concepts to be learned and strongly influenced by the method of teaching.

3 THE ADDED VALUE OF BLOCK MAGIC COMPARED TO TRADITIONAL METHODS

There are several advantages that Block Magic can offer compared to traditional teaching. In particular, in terms of teaching, Block Magic Training Kit is planned to:

1. Offer learning of a broad spectrum of skills while providing a highly flexible and customizable teaching plans.
2. Make a game that allows children to learn in a fun way without the perception of formal "assignment", so as to maintain a high level of attention, motivation and satisfaction.

3. Produce a "guided" teaching path, which is customizable to the learner's characteristics and adapts the games / exercises selection (both in terms of of target skills and of difficulty level) based on responses obtained in the previous session regardless of the child's cognitive or biological age.

4. Evaluate and stimulate in a "soft" manner, i.e. without formal evaluation, the child's potential and the competence acquisition regarding a specific skill, as well as the learning curve is a response to external stimuli, giving the teacher the opportunity to intervene at any time.

5. Be very simple to use so that it can be used with or without the constant presence of the teacher.

6. Interact with the teacher to define the educational objectives. The teacher can interact with the system by programming it in a way suited to the specific objectives and end-user responses, and may participate in the educational game as a facilitator or support, or as an observer, so as to collect further information on children performance, such as the degree of enjoyment, the continuity in the game, etc.

At the same time, the Block Magic is a hybrid system with both physical and digital components. The learning experience consists of the students manipulate physical objects (i.e. the logical blocks) in a rather traditional way. On the digital side, the software selects the learning exercises, tracks the student and analysed his/her actions and provides immediate feedback. Apart from receiving the vocal feedback, children have little or no interaction with the digital system. So learning with Block Magic is very hands-on compared, for example with computer games.

4 MAGIC BLOCKS AND SKILLS

The overarching goal of Block Magic is to help young learners to learn autonomously. This, the authors believe, is a basic life-skill, of critical importance for their future development. Block Magic provides an attractive and highly motivating approach to teaching skills which will be important for learners in later life. In other words, Block Magic will support the acquisition of life skills in target populations where alternative teaching methods may be less effective.

Block Magic aims to create learning activities promoting the development of creative, mathematical, logical, language, strategic and social skills in normal children and in children with special needs.

The next sections describe each of these skills separately.

4.1 Mathematical skills

Before learning to do formal mathematics, by performing e.g. summing or subtracting, children need to build the foundation of the future mathematical operations. According to [1], this is done by constructing ideas about mathematics that cannot be directly thought, such as quantification, order, sequence, seriation and classification. Furthermore, children's mathematical and logical thinking develops by being exercised and stimulated. "Teachers who encourage children to put objects on all kinds of relationships are promoting children's emergent understanding of mathematics."

Quantification, for example, "is the basis of formal mathematics and is a synthesis of order (the basic understanding that objects are counted in a specific sequence and each object is counted only once)" [2]. The author claims that "children as young as two may be able to count to 10 or even 20 , but if they do not link their counting to quantification it is no different to memorizing their ABCs or a list of names, like Bob, Joe and Sara."

Equality is another such concept which understanding leads a step further to understanding mathematical relationships.

Sorting is a basic mathematical skill that is used in more complex areas of math. Small toys and colour and shaped blocks that allow to see and manipulate patterns are good tool for teaching the concept of sorting [3].
4.2 Logical skills

Logical skills deal with reasoning which refers to the capacity of human beings to make sense of things, to establish and verify facts\(^3\). Logical skills could be considered a specific sub-class of the mathematical skills.

Classification, for example, “is the ability to group like objects in sets by a specific characteristics. The synthesis takes place by children interacting with objects and putting them in many different types of relationships.” [3]. An easy attribute to start with is colour and once children have exhibited an understanding of the concept more complex attributes, like shape or size, can be involved in the exercise [4].

4.3 Creative skills

'Creativity' is a term that might be understood by different people and in different contexts in many different ways. Commonly, people relate it to arts and crafts, such as visual arts (e.g. ceramics, drawing, painting, sculpture, etc.) and music, or more recently with performing arts or photography. NACCCE [5] defined creativity as an “imaginative activity fashioned so as to produce outcomes that are both original and of value”.

As stated in the Official Journal of the European Union [6], “all levels of education and training can contribute to creativity and innovation in a lifelong learning perspective: the early stages of education concentrating on motivation, learning to learn skills and other key competences, and subsequent stages focusing on more specific skills and the creation, development and application of new knowledge and ideas”.

Creativity is viewed by many educators as an important part of the preschool. According to [7] creativity involves two processes: thinking and then producing.

The literature reveals that for stimulating creativity in young children, the following apply\(^4\):

- creativity can be linked to artistic field (e.g. drawing or crafts) and also to problem solving and idea generation
- the focus should be on the process, not on the product; there is no right or wrong
- teachers should encourage experimentation, and should stimulate risks taking in save environments
- from the teaching side, promoting creativity could be considered the teaching of skills that will allow the child to be creative, such as the skill of using scissors ([7], p116).
- unexpected objects could be used to spark children's imagination [8].

4.4 Strategic skills

“A strategy is a plan of action designed to achieve a vision. Strategy is all about gaining (or being prepared to gain) a position of advantage over adversaries or best exploiting emerging possibilities. As there is always an element of uncertainty about future, strategy is more about a set of options ("strategic choices") than a fixed plan”\(^5\).

Strategic skills are often linked to planning and problem solving. It also involves logical thinking and prediction.

4.5 Language skills

Language skills in young children, including in pre-school involve development of vocabulary, but also a range of flexibility and control over the use of words in sentences and conversation.

Young children can practice their language skills by “describes items according to size, shape, color, and function ”, “speaks clearly and fluently”, “uses varied vocabulary and tries new words”, “begins to use more complex sentence connectors (e.g. because, if, when, although, after, before)” [9].

Acquiring language skills comprises among other things, vocabulary development, comprehension, concept sorts. “Preschool children’s vocabulary can be improved by simply listening to books read

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\(^3\) http://en.wikipedia.org/wiki/Reasoning

\(^4\) Note: the list is neither ordered nor exclusive

\(^5\) http://en.wikipedia.org/wiki/Strategy
aloud. However, vocabulary gain is greatest if the meanings of the words are discussed directly, preferably before and after the reading. “Concept sorts provide children with the opportunity to think and talk about how they can compare and contrast items to develop and understanding of concepts and attributes.” [10].

Sherard [11] argues that Geometry should be considered basic skill “since it is important aid for communication”. Many geometric terms are used in everyday life, for example when giving location directions or describing shapes of objects, making the geometry terminology essential.

Furthermore, Coggins et al [12] suggest that providing non-linguistic mathematics materials facilitates the acquisition of mathematics language. In particular, by using manipulatives, such as the attribute blocks, children can learn new mathematical terms, for example “edge,” “corner,” “arc,” “rotate,” and so forth and practice to use them correctly. According to the authors, concrete materials often facilitate understanding of mathematics languages. This approach could be particularly appropriate for non-native speaking children.

Assigning two or more children to perform a task (e.g. to solve a logical problem) will not only stimulate the logical or strategic skills together with the social skills, but also will stimulate the acquisition of language skills. The children will explain, plan and even debate and discuss. The children will find themselves in the need to clearly communicate their ideas to another peer, provide arguments in defense of their proposal, etc.

### 4.6 Social skills

According to Wikipedia[6], in behaviourism, social skill is any skill facilitating interaction and communication with others. Social rules and relations are created, communicated, and changed in verbal and nonverbal ways. The process of learning such skills is called socialization.

Social and emotional skills that have to be taught to young children, according to [4] are:

- Following rules, routines, and directions
- Identifying feelings in oneself and others
- Controlling anger and impulses
- Problem solving
- Suggesting play themes and activities to peers
- Sharing toys and other materials
- Taking turns
- Helping adults and peers
- Giving compliments
- Understanding how and when to apologize
- Expressing empathy with others’ feelings
- Recognizing that anger can interfere with problem solving
- Learning how to recognize anger in oneself and others
- Learning how to calm down
- Understanding appropriate ways to express anger

Deficits or excesses in social behaviour interfere with learning, teaching, and the classroom’s orchestration and climate. One’s social competence is linked to peer acceptance, teacher acceptance, success of inclusion efforts with students with disabilities, and post school success. Displaying poor social skills is likely to get one rejected by others (other kids don’t like them and won’t associate with them) [13].

Fox and Lentini [4] state that in order to teach social skills systematically and efficiently, teachers need to be aware of the three stages of learning: “The first stage is skill acquisition—the skill is introduced to the child; the second stage is fluency—the child has learned the skill and can use it easily; and the final stage of learning is skill maintenance and generalization—the child can use the skill over time and in new situations”.

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Social Skills involve learning tolerance of others, taking another’s point of view, and being able to move past one’s own personal needs and wishes [10]. Furthermore, social skills include the ability to:

- express wishes and preferences clearly;
- assert own rights and needs appropriately;
- express frustrations and anger effectively and without escalating disagreements or harming others;
- gain access to ongoing groups at play and work;
- take turns fairly easily;
- show interest in others;

Children need to exercise these social skills in supportive settings for developing a social understanding and becoming socially competent. These skills take time to develop and must be rehearsed by young children so they can become aware of the effects their actions have on others.

Some of the social skills that would be on focus in Block Magic include practicing verbal communication, respect towards other peers and tolerance and openness to different opinions/strategies, etc.

5 LEARNING SCENARIOS AND ACTIVITIES

Block Magic aims to create learning activities promoting the development of creative, mathematical, logical, language, strategic and social skills in normal children and in children with special needs, in a playful and autonomous way, through the use of the training kit.

The methodology proposed in the project is designed in such a way as to encourage a progressive and steady process of learning and knowledge enrichment throughout the school year. The training makes use of "laboratory" activities, i.e. active teaching methodologies based on procedural activities that actively involve students in the learning process. The training comprises a set of activities as described below:

1. Identification of learning objectives: teachers, after reading the manual they have been provided, define the learning goals of both the class and of the individual children, selecting how to use the Kit: number of sessions, duration, reference scenarios, etc.

2. Users’ familiarization with the tool: the first day, the teacher shows to the children the game (the blocks) and opens a free play session, that aims at familiarizing them with the instrument and the identification of technical problems. The duration of this phase is defined by the teacher.

3. First play session: during the first day, or later (depending on the decision of the teacher), children playing with Magic Block by performing a series of exercises chosen by the software randomly from the database it contains. This first session allows the children to get to know the instrument. Meanwhile, the software creates for each user "base line" reference, regarding the user’s specific skills targeted by the training. Based on this "base line", the teacher and/or the software will calibrate and customize the training for the individual child, identifying the less developed skills and defining accordingly which exercises to be proposed in the next game session.

4. Analysis of data collected: at the end of the game session, the teacher will access the database of the results collected by the system and will use this data to (possibly) restructure the training of the child, integrating it with information obtained through direct observation. To this end, the teacher can manually change the software settings by increasing the number of exercises for a specific skill, so as to reinforce the work in that specific area.

5. Play sessions: the play sessions will be repeated in the manner and time set by the teacher based on educational objectives previously identified, the characteristics of the target group and the results of the previous session. At the beginning of each game session, the teacher may decide to manually select the software settings. Otherwise, the software will select the group of exercises on the basis of the results collected and analyzed previously.

Five of the 6 skills targeted by the project, can be taught both individually and in group, while the "social skill" can only emerge under conditions of group play.
5.1 Example learning activity: “Missing a piece in a picture”

This activity consists of the child searching for a missing piece from a picture, which the system has selected automatically and displays on the monitor. The teacher might provide the picture as complementary material (i.e. an A4 paper sheet with the picture) as well. In the picture an object is made out of logic blocks, i.e. geometrical forms are used for drawing (see Figure 2a). According to the literature, the use of unexpected objects, such as the triangles that will form the leafs of a flower, could spark children's imagination.

The software will stimulate the child to identify the object

“What is this?

Afterwards, the system will stimulate the child to reconstruct it physically on the table with the blocks:

“Isn’t that a colorful flower? Can you find all the pieces and make your own flower?”

The child than selects one by one the pieces that are shown on the picture and constructs the flower on the table. On each selection the software describes the selected piece, naming the relevant attributes and stimulates the child to continue to play, for example:

“Good, you have selected a big blue triangle that will make one of the leafs. Can you find another one”.

If the selected piece is not correct, the feedback will be:

“Uhhhm, this is a [the chosen form, such as “small red square”]. But there are no [the selected block shape, such as square]s in this flower. Look at the picture and find another block.”

Once the child identifies all the blocks represented in the picture and reconstructs the image the software should set the next task for the child, i.e. find the missing piece.

“How nice! Now we have the same flower as in the picture. The leafs are made of triangles. Ohhh, but there is a missing piece to complete the flower? Can you find out which one is it?”

The child needs to identify that the color pattern that is used in the construction of the flower, i.e. only big triangles are used for leafs, while the colors are following the pattern “blue, red, yellow, blue, red, yellow”. Thus, the missing piece is a big yellow triangle.

At this point the game becomes a sort of ‘treasure hunt’ in which the child is looking for is the big yellow triangle. The child must find the block by selecting it with the magic wand. At the end of each step, until the correct block is found the child will receive feedback which depends on the choice, such as

“What you have chosen is a [description of the chosen block]. What you are looking for is not [the color of the chosen block].”

The child will need to touch with the magic wand another block but it should not be the same color of the previous block, but even in this case he will receive the same verbal feedback:

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7 http://www.wikihow.com/Develop-Creativity-in-Preschool
“You have selected a [description of the chosen block]. What you are looking for is not [the color of the chosen block].”

He/she will need to touch the correct color and the software will tell him

“Good! This is [description of the chosen block]. The color is correct but what you are looking for is not [the shape chosen by the child].”

The child will need to continue to touch blocks until the correct block is found and the software will give a positive response:

“You’ve been great! You found the block that was missing! It was the big yellow triangle”.

6 DISCUSSION AND CONCLUSIONS

In May 2012, the first prototype of Block Magic was evaluated with teachers from infant and primary schools in Germany [14]. This first evaluation confirmed the principles described below and used in the design of the Block Magic learning activities.

The described learning activity is an example of a series of activities designed for the second Block Magic prototype which will be tested and evaluated during 2012-2013 academic year. Here we describe several of the axes which the authors believe are important to consider in the activities design for promoting learning and triggering the six basic skills described in section 4.

6.1 Language used in feedback

Block Magic counts on constant feedback which the system produces on each activity of the player. This feedback is important for stimulating certain skills. For example, for stimulating language acquisition it is important that the verbal feedback changes every time. Such functionality is easily implementable within a software system such as Block Magic which could allow random selection of phrases with the same meaning.

Furthermore, in group play, the software should stimulate the children to interact, through appropriate feedback. For example using instructions such as “Find together all the pieces”, “Have you all agreed to select it?”, “Can someone suggest which block goes in that train?” or “Was there a different suggestion?” the players could be regularly reminded in a rather mild way about certain social principles, such as tolerance, agreement or listening to others’ points of view.

6.2 Tracking the child’s advancement

Block Magic provides exercises of varying difficulty. On each learning session the child will play a set of games automatically selected by the system. The goal is to increase the level of difficulty according to the learning pattern of each child and based on the current level of competence of the six targeted skills.

In the easiest level of the exemplified activity, the child will be given the image in which all the forms of the blocks are available (see Figure 2a). There is one missing piece and the picture does not provide only one attribute of this missing piece, i.e. the color. The task will be completed by child correctly identifying the form (i.e. a triangle), so any color will be considered correct. In this level, the pattern with original size is important for facilitating the children to make a link between the picture and the physical blocks that they would manipulate. Additionally, the teacher can manually diminish further the difficulty level by decreasing the size of the set that is manipulated, i.e. lowering the number of blocks that the child plays with. The smaller the size of the set, the easier it will be for the child to find the correct form. In the easiest level the child can be provided only the big forms (i.e. 24 blocks, instead of 48).

In the medium level (see Figure 2b), the child will be looking at a picture in which the missing piece is missing completely. The child should identify all the attributes of the missing piece (i.e. big yellow triangle). In the hardest level of the exercise, the picture will not provide the exact representation of the blocks that construct it (see Figure 2c). The child should imagine the form that best fits.

For stimulating the learning, the Block Magic system will select specific set of exercises for each learning session. The child’s performance in each exercise will be tracked and recorded, thus allowing the data to be analyzed and the system to acquire knowledge about the child’s degree of learning of the different skills, the degree of interest, the learning curve, etc. An advantage that this approach
provides is that there is no explicit consideration of the child’s physiological age, allowing, apart from the other advantages, flexibility for the system to be used with normal and disabled children. In the last case, the exercises will be selected according the child’s mental age and advancement.

For selecting the right set of exercises, the algorithm will use a decision system based on a Gaussian curve. The major portion of the exercises will fall within the competence of the child, while a smaller percentage will be represented by exercises outside of these skills. In a single session, the set of exercises could be of different difficulties and might be targeting some skills more than others.

6.3 Match pedagogical objectives to individual and group play

Specific pedagogical objective of the above described scenario is to provoke children imagination by using unexpected objects (i.e. geometrical shapes in the drawing). Thus, the targeted skill is creativity. It will be mainly triggered while the child is reconstructing the flower. Furthermore, the process of finding the missing piece will trigger logical skills. Also, language skills/ world acquisition is stimulated, through numerous repetition of the blocks attributes and variation in the wording of the instructions given by the software on each action of the child.

This scenario could be practiced by a single kid or in a group. If students work in a small group, one child is selected as a leader and operates the magic wand for consecutively selecting different blocks in order to check whether the selected one is the correct one, while the rest of the group will be giving suggestion. On each step the system provides feedback which the children use for logically discarding some blocks and selecting a new one until the correct block is identified. The system stimulates the discussion and negotiation in the group through the feedback it provides. When played in a group social and language skills will be also practiced, while the children discuss what the object is and what is the shape or the color of the block they as a group need to select.

To sum up, in this paper we introduce the Block Magic – a hybrid system where pre-school and primary school children (age 2.5 to 7) can manipulate physical objects (logical blocks), while the exercise selection and step by step feedback is provide by an “intelligent” digital system. We have presented the preliminary results of the design of the learning activities, emphasizing on the importance of careful use of the language in the feedback, the advantages of tracking the child during learning activities and identifying how specific pedagogical objectives relate to individual or group play.

Further developments will explore how children work with the system both individually and in groups in relation to the building of the mentioned skills.

AKNOWLEDGEMENTS

Block Magic project has been funded with support from the European Commission (Lifelong Learning Programme project No. 517936- LLP-1-2011-1-IT-COMENIUS-CMP). This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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5th INTERNATIONAL CONFERENCE OF EDUCATION, RESEARCH AND INNOVATION

Madrid (Spain) 19th - 21st of November, 2012