# HAND IN HAND
## *Maths and Storytelling together in an Educational Game*

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Abstract: In this paper, we describe a novel approach to teaching early mathematical concepts to young children. The approach aims to merge storytelling and Maths. Evidence show that through dramatic games and role-playing activities young children (aging from 5-7 years old) learn to master new knowledge, to fit in a new school setting and to socially relate with their peers. So taking this evidence into account, it is possible to devise an innovative learning scenario that teaches early mathematical concepts by telling and creating stories. To explore this idea, we first started by developing an application that provides children from 5 to 7 years old to learn simple maths concepts by interacting and playing in a game. Then, we take this project a step forward and explore the introduction of storytelling by devising an engaging approach of presenting the maths concepts through the use of a story.

## 1 MOTIVATION

Stories have always been part of human culture, and although civilization has passed through several changes (cultural, evolutionary, etc.), they remain inside and around us. Each of us is capable of telling a story about his/her own life, each of us stores in his/her memory what happens in the world in the format of stories, and each of us uses stories to understand not only what surrounds us, but also what our role is in such a big play.

Young children start to construct their first stories by imitating their parents' daily routines and actions. Under such conditions, children introduce variations in the flow of their imaginative play (i.e., introducing new elements or situations in their plays) and through this, they acquire knowledge about the external and mysterious world that surrounds them.

In their early childhood (2-6 years old), children tend to use fantasy activities to explore the differences between right and wrong; develop their communication skills; and, develop their imagination and capacity to play. At middle childhood (7-12 years old), children start attending school - This period is dependent to the age children start attending school.- and are first exposed to formal forms of knowledge (such as reading, maths, etc.) and to the discipline of being a student. Nevertheless, new forms of make-believe and fantasy take place in their lives: video games, computer games, television cartoons and the opportunity to participate in *dramatic games* and *theatre performances* at school. There is evidence that through these games children at these ages learn to master all the new knowledge, to fit in the new school setting and to socially relate with their peers.

Further, dramatic play promotes social competence, emotional development, or general well-being of the child, by enhancing each child's capacities of imagery and developing overt social and behavioural skills. Additionally, children have become capable of using their capacity for operational thought in the ordering and sequencing performances necessary to play rule-based games. Based on these finding, it is clear that drama education is an excellence medium to convey learning and knowledge acquisition.

From another perspective, there is also the fact that the digital games industry increasingly exerts considerable influence in the lives of children and teens, emerging the opportunity to use the games to create learning experiences that are interesting and enable them to acquire or strengthen knowledge by

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enjoying themselves (Prensky, 2007).

Taking all these findings in consideration, it is possible to envision the application of such methods in a Mathematical learning environment. The research projects developed in the field of educational storytelling have as their main goal to portray educational material in an interactive format that aims to provide a higher level of engagement of learners. Learners no longer have a passive role in their learning process, but they take part now in interactive and appealing situations, in which their actions matter. The knowledge acquisition processes itself in a more implicit and natural way, since it is now mainly achieved by a direct exploration and intervention of the learner of different *learning* situations.

## 2 THE IDEA

The idea of portraying Mathematics into a make-believe environment emerges from the success of several research projects which used a narrative approach for attaining educational and edutainment objectives. For example, the Networked Interactive Media In Schools (NIMIS) project – in particular Teatrix application (Machado and Paiva, 2002), the POGO project (Rizzo et al., 2003), Adventure Author (Good and Robertson, 2003), etc.

The envisaged environment not only promotes the acquisition and development of mathematical concepts and structures, but also the integration of the needed reflection for the understanding of mathematical reasoning process.

Many psychologists and educators have studied and investigated the influence of narratives and stories during child development phases. It is now very clear that narrative can be an important vehicle to structure the knowledge and to help in the process of meaning making (Mott et al., 1990). From Malone's perspective (Malone, 1984) narrative plays a central role in memory by providing an organising structure for the knowledge.

Other educators complement such ideas by arguing that imagination is a crucial and central factor to promote an effective learning process. The use of narrative to convey such an important knowledge as Mathematics can be seen as quite relevant and appropriate. In fantasy and make-believe contexts, children allow to explore new situations, since they know that in such contexts they are in a safe environment. Additionally, make-believe activities are repetitive by nature so it is possible for a child to practice multiple times the same situation before achieving a proficiency level on a new concept.

Our aim is to develop such an intelligent learning environment for young children aging from 5-7 years old (pre-schoolers and 1st graders) who are challenged with new situations as: acquiring new knowledge, finding their places in a new school environment with more rules and to social relate with their teachers and colleagues.

By experiencing new and varied situations and by sharing multiple points of view, children can develop new skills that might help them to face the real life problems. Also, by adding fantasy and imagination to a learning environment, we reach the concept of drama education (Bolton, 1998).

## 3 THE ENVIRONMENT – MATHS4KIDS

The environment was design in such a way that children interact with it and have the chance to strengthen their Maths concepts, by gaining knowledge about the geometry, the numbers and the numerical relations through the use of the technology. Besides the maths concepts, we tried to instil the concept of mass/weight of an object associated with its numerical value.

The project was developed with a participatory design approach (Schuler and Namioka, 1993) through several meetings were promoted with Preschool Educators. Their role was basically to choose the pedagogical content of the application and to validate the interaction forms used. The content chosen was:

- Discovering the numbers:
  - Identify the number and the counting system;
  - Quantify objects and express the cardinality;
  - Develop numerical capacities.
- Numerical Relations:
  - Relations between numbers;
  - Develop arithmetic skills.
- Identify/Categorise objects
- Temporal and Logical Sequencing
- Concept of mass/weight of objects.

Fifteen children participated in intermediate and final usability tests – aged from 5 to 7 years old.

### 3.1 Mini-games

Six mini-games were developed which include counting units and tens, ordering by size or age: arithmetic calculations by taking into account the weight of the objects – using a virtual scale -, construction of object sequences and grouping objects based on categories and number of the objects. For global coherence of the application, the interface, interaction and reinforcing mechanisms were maintained the same in the main menu and mini-games. In case of needing help, a video is always available.

In Figure 1, the mini-game joins the concepts of counting and association by comparison. It consists in putting the right number of a specific vegetable in the *bag*. It is possible to *break* the bag - if the necessary strength is applied in it. In this case the bag breaks and the vegetables fall and the child player receives less points. The bag breaks in a non-deterministic way, and it is possible to break in multiple points due to the dynamics imposed to the bag. Although not trivial this discovery (usually only the youngest discover it spontaneously) it is an amusing feature of the application.

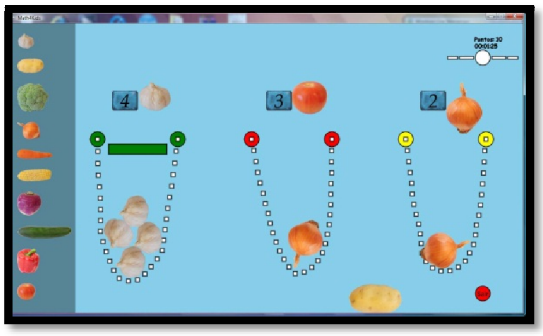


Figure 1: Counting and Grouping.

## 4 EVALUATION

The tests were performed with a group composed by 15 children aging from 5 to 7 years old. The children were arranged in groups of three to interact with the application. The number of elements in a group was imposed by the lack of time to conduct an individual interaction with each child. The teacher was asked to provide groups with mixed ages (children ages varied from 5 to 7 years old) and also with mixed personalities and development skills.

In this first prototype we assessed only the acceptance of the different exercises by the children and also a new interaction approach. In terms of interaction the approach is quite challenging for the children – and even for adults – since it is based on Physics Laws. Both issues were successfully evaluated by the children although the way of interaction was more appropriated for the oldest ones.

Sometimes, an interesting event occurred when some children felt frustrated they started to amuse themselves by moving the objects around and watching the way they collide. In these cases, the Preschool educator had to intervene and call their attention to the main goal of mini-game. The oldest children were able to solve the mini-games in a very fast and spontaneous way.

From corporal signs, we were able to evaluate the interest shown by the children, which were always high due mostly to the engaging colours, to the interaction of the objects between themselves, and the sounds played for specific actions. When children solved the problems correctly, they were supported with a positive message and a sound. To what concerns to negative feedback, the strategy was to underline the incorrect results with red colour, avoiding the use of negative messages.

By assessing the acceptance of each exercise we wanted to guarantee that children are able to recognise the mini-games that are presented and that from this point forward we can enhance the application with the narrative approach.

## 5 ADDING STORYTELLING

The main idea is that the mathematical concepts may be introduced in the form of an interesting plot where children play a specific role – by choosing a character to control - and alone or collaboratively with other children find the solution of a mystery or a problem. For the creation of the story to be played by the children there are also different possibilities since it can be:

– Scripted by the teacher: This mode is quite interesting from a teachers' perspective because it allows them to define the concepts to be presented to the children. From another perspective, this poses an additional challenge for the development of the Intelligent Learning Environment (ILE), since it must accommodate the possibility of teachers – usually without technical skills – to introduce concepts and learning objectives in pre-defined story templates.

– Interactive: This mode poses also very interesting challenges, since it allows the children to

interact with an environment that covers a wide range of mathematical topics but their progression depends only on their own decisions/actions within the environment. It is also possible to envision the introduction of a tutor like character that guides the children during the interaction.

In the following subsection, a small example of the environment is going to be presented, with the aim of clarifying how the application is going to be developed.

### 5.1 An Example

Children gather together around the table enter Maths4Kids: *"Welcome, to the Mathematical land... today, we will start with a story about our friends Mr. Onion, Mr. Tomato and Miss Carrot. They decided to go to the park but they need your help to get there!"* From this piece of information, children should be introduced to the story scenario and they should discover what they have to do to compose a sequence with the vegetables to reach the park. In order to arrange the vegetables in the correct sequence, children should pay attention to the piece of the story that the vegetable is telling whenever it is picked.

## 6 TECHNICAL DESCRIPTION

The development of this prototype was achieved by using Microsoft´s XNA Framework and Microsoft´s XNA Game Studio 3.1, which enables a way to easily create video games for Xbox 360, Windows and Zune by using the optimized cross-platform libraries based on the .NET Framework in the C# programming language.

## 7 CONCLUSIONS

This paper presents an application that portrays a set of mini-games that cover initial Maths concepts, and explores the idea of enhancing such application with a storytelling approach. With this approach we argue that it is possible to promote an engaging learning environment where children are motivated to explore new theoretical concepts just by interacting within an already known environment/activity – story creation or role playing. Some initial evaluation tests were performed which guarantee us a set of results that will allows in the future to compare with the storytelling version of the application.

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