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Educational Application for Preschool Children

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Declaration

I declare that I completed this thesis individually and used only the references mentioned in the list enclosed. I have no relevant reason against utilization of this writing by course of §60 Law no. 121/2000 about copyright, related laws and modification of some of them (Authors Act).

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Abstract

Children are now living in a world that is no longer filled with real-life experience only: they can see fairies and monsters coming to life in modern rendered movies, and play with complicated electronic toys their grand-parents would consider too complex to be even called a toy. Contemporary children often know how to operate the newest mobile device, but can struggle narrating a short story or describing their summer vacation experiences. Such problems often cause a postponement of the school attendance, a trend that is still present in today's society.

We tried to look further into special aids designed to help preschool children preparing for their school lives and ensuring smooth start in the educational process, and designed an application that would help them merge the fascinating experience of the interactive world together with acquiring the knowledge and skills they need. We intended particularly to discover how should an interactive educational application look like to appeal to young children and comply with the concept of learning through playing. Taking similar projects into account, we concentrated mainly on the visual experience, which is the most important area considering the target group - preschool children.

This work thus contains a research into children's school readiness, guidelines for design centered on young children and a description of the design process of a prototype we created that is based on these guidelines. We intended to create an interactive educational application that aims to provide children with a plausible and beautiful visual experience, teaching them the basics while remaining playful, providing them with joy that results from an accomplished task and motivating them so to proceed further in the educational process.

Abstrakt

Děti již dávno nevyrůstají ve světě nabízejícím pouze vlastní zkušenost: mohou spatřit ožívající víly i obludy v moderních renderovaných filmech i hrát si se složitými elektronickými hračkami, které pro jejich prarodiče představují komplexní zařízení daleko za hranicí běžných dětských hraček. Současné děti tak často zvládnou obsluhovat nejnovější model mobilního telefonu, ale zároveň mohou mít problémy s vyprávěním krátkého příběhu nebo dokonce vlastních zážitků z letních prázdnin. Takové problémy často vyústí v odklad školní docházky, trend, který můžeme v dnešní společnosti stále pozorovat.

Pokusili jsme se blíže prozkoumat pomůcky, které mají dětem pomoci připravit se na školní život a zajistit jejich hladký start ve vzdělávacím procesu; navrhli jsme také aplikaci, která by měla dětem usnadnit splynutí tolik fascinujícího interaktivního světa se získáváním znalostí a dovedností, které potřebují. Zejména jsme se soustředili na odhalení toho, jak by interaktivní výuková aplikace měla vypadat, aby předškolní děti oslovila a splňovala koncepci učení hrou. S ohledem na podobné projekty jsme se zaměřili především na vizuální stránku, která je pro aplikaci určenou cílové skupině - předškolním dětem - ta nejdůležitější.

Tato práce tak obsahuje výzkum v oblasti školní připravenosti, instrukce pro návrh cílený na předškolní děti a popis návrhového procesu prototypu, který jsme vytvořili následujíce tyto instrukce a doporučení vyplývající z výzkumu. Snažili jsme se vytvořit aplikaci tak, aby dětem dokázala nabídnout přesvědčivý a pěkný vizuální zážitek, naučila je potřebné základy skrze hru, poskytla jim radost ze splnění úkolu a motivovala je tak postupovat dál ve vzdělávacím procesu.

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Introduction

The problems context

In the Czech Republic, children are supposed to start their school attendance at the age of six, if they prove to be school ready (the Czech Republic is one of a few states in the European Union that takes both the age and the school readiness into consideration). More precisely, the compulsory school attendance starts at the beginning of the school year that follows the day of the child's sixth anniversary [1]. If a child is proportionately mature, he or she can start going to school despite reaching the age of six *within* the school year (from September to June). On the other hand, if a child is not physically or mentally developed adequately, and his or her guardian submits an appropriate request, the school headmaster can postpone the school attendance of the child by one year. Such request need to be supported by statement of a paediatrician or a special consulting institution [1].

In the past decade, we witnessed a trend characterized by a slightly increasing number of children having their school entrance postponed. According to [2], 14 percent of children achieving school age in 1997 had put their school attendance off, while their number is likely to have increased to 22 percent this year.

There are many different reasons that lead to the postponement of the school attendance. According to [1], parents should consider this option in the following cases:

- the child is weak in terms of health
- the child's cognitive development has been delayed
- the child's cognitive development is slower or uneven, or one of its areas are significantly delayed
- the child is immature in terms of work capacity
- the child is immature in the emotional and social fields.

It is extremely important to mention that the child should always be examined from a broad perspective and his or her whole life situation and skills should be taken into account while judging the school readiness [1].

At other times, the child is school ready and growing up in a good life environment, but parents ask for the postponement anyway, claiming the child is still *too playful,* and that he or she will surely be *better, more skillful and successful next year* [1]. In this case, the right time to start a new phase in the child's life could be missed.

Some children achieve the school readiness purely by aging, others may need some help or support in the fields they are not yet mature. This support should be provided in the nursery school (including some special plans targeted at children who need special care), within the family, or in a preparatory courses that are offered by primary schools and that have gotten more common recently [3].

Motivation and aims definition

Even though the development of central nervous system is crucial in the overal development of children's skills, it can be necessary to work purposefully with the child to ensure his smooth start in the school life [4], especially if his or her school attendance has been postponed. Taking on simple exercises develops many areas of basic skills and it can also help the child to became part of a group faster and easier [5].

In case a parent assists the child while taking on exercises, every progress can be easily observed, and seeing a child completing the tasks assigned can erase the doubts about his or her school readiness. On the other hand, it can point to the areas that need to be given special attention. We also shouldn't forget about the importance of the parent's presence and support [5].

It seems that many aids for preschool children have been introduced recently, so why is the amount of children having their school attendance potponed increasing? In this research work, we would thus like to explore and study the school readiness aids, talk to educators and special pedagogues, and learn about the exercises that are offered to children in special publications. After gaining the insights necessary, we would like to propose a prototype of an interactive educational application. Such application should mainly serve as a guideline for parents, to explore what their child can do and

where a help is needed, and provide inspiration for other educational activities. This way, the application can be useful to children who had their school attendance postponed, and serve the children who are only preparing for the school entrance as well. We don't aim to create any special tool that could be used for judging a child's maturity or provide a complete overview of his or her skills; we aim especially to research and discover which aids are the most suitable for working with children in the framework of a digital output media such as iDTV, design one following the discovered guidelines and verify that it can be accepted by children, parents and psychologists.

Part I: Research

Chapter One:
General research on school readiness

According to [6], we should always set up the goals of the research before the start: define what sort of information we aim to discover and which means are we going to employ. Then we should talk to people who will use our product. In our case, things are a bit more complicated, as we can't expect preschool children to define which sort of application do they need or they would like to work with. As our aim was to discover which sort school readiness aids were available and what sort of application was desirable, we decided to talk to all the people who are involved in the school enrolment process: paediatricians' nurses, child psychologists, special educators, nursery school instructors and finally the primary school teachers. Before starting with interviews, we did some research in the library and over the Internet to learn about the school readiness and prepare a set of questions for the specialists.

1.1 School maturity and readiness defined

The terms "school maturity" and "school readiness" are often mentioned together, but their meanings are slightly different. School maturity can be defined as reaching such level of development (in the physical, mental and emotionally-social areas) that allows the child to became part of the educational process without any difficulties [1]. The fields that are considered while judging the school maturity are listed below:

- physical (somatic) development and health
- the level of cognitive functions
- the level of work capacity (work prerequisities and habits)
- the level of character maturity (emotionally-social).

School readiness is more complex: it embraces all the competence in the cognitive, emotionally-social, work and somatic areas that the child acquire and develop via learning and gaining social experience (in the nursery school for instance) [1].

This competence, along with the amount of schoolwork children are supposed to master during the nursery school years, is discussed into details in the Instructional Framework for Preschool Education [7] and in its manual [8]. According to the Manual, each nursery school has to create their own didactic blocks: this way, educators can better adjust the teaching to the children they have in classes.

Generally, the school readiness depends on the most basic skill: the skill *to learn*. Its most important aspects are listed below [1].

- **self-confidence**: the child should feel full control over its movements and be convinced that if it starts an activity, a success will ensue, and the adults will be here to provide help if needed
- **curiousness**: it is good and interesting to learn and gaining knowledge is pleasant
- **the ability to act with an aim in mind**: the child should wish to influence the developments, and feel like it is able to
- **self-control**: the ability to adapt and control its own behaviour
- **the ability of working together with others**: this depends on how a child is understood by the others and how does the child understand others
- **communication skill**: the child feels a need to exchange its thoughts and feelings with others
- **co-operation skill**: the child is able to find a balance between its needs and the needs of the others while working together.

1.2 Interview with a paediatrician's nurse

After having learned about the concepts of both school maturity and readiness, we went to ask a paediatrician and then a special educator, whose statements are required when postponing the school attendance. We were interested in the process that takes place when a child is considered not ready for school, and how is then such child treated.

The nurse told us that their authorities cover only the somatic aspect, and if the parents are unsure about the mental side, they are sent to a special institution [9]. This process can be also suggested by the nursery school the child is attending, or recommended based on the school maturity test (which will be discussed later). The nurse claimed that they recomment the school postponement usually in case a child is too sick or weak in health.

1.3 Visiting special institutions

As we were given the adress of the special institution the health center usually send children to, we went there to talk with a child psychologist. Such special institutions are called Pedagogical Psychological Advisory Centers and are established for each district in Prague (we will refer to them simply as PPP).

In a PPP, a child can take the school maturity test, if it didn't take one at the nursery school or if its school attendance has been postponed last year. In the Czech Republic, such test is also called Kern-Jiráskův test školní zralosti. This test consists of fulfilling three tasks:

- draw a human figure
- imitate cursive writing according to given template
- copy a group of points.

The school enrolment is postponed usually if a child draws a cephalopod instead of a character with details such as fingers, eyes and mouth, produces a scrawl in place of handwriting or doesn't copy the appropriate number of points [10,11].

In case this happens, the PPP offer help in form of regular visits: the child comes to the institution according to the timetable planned by the special educators, and parents are given literature containing examples of activities they should practise with their child.

The aids offered by PPPs vary from every institution, but they generally consist the following:

- brochures with lists of activities and similar publications (for parents)
- books, coloring books and workbooks (for children)
- special equipment for easy drawing and writing, including ergonomic color pencils and pens and extensions focusing on inducement of the right grasp of the writing tool (with the three fingers)

Books, brochures with special activities for children and workbooks will be discussed into more details in the next chapter, where we provide an overview of recommended activities.

The aids that stood out the most were the ones for easy drawing and writing, that have evolved a lot recently. According to [1], the correct, pinch-like grasp of the pen or pencil should be induced already at the age of three. Special extensions or attachments exist nowadays that make the process of learning how to hold the drawing tools properly much easier. Such aids thus let the child to keep the fingers and wrist relaxed and concentrate solely on producing the right shape [4].

***Figure 1**: special extensions can be used by both lefthanders and righthanders, and as they are offered in a variety of colors, they are usually well accepted by the children [11].*

There were also many types of special colored pencils and pens designed directly for preschool children. To keep the hand relaxed while still holding the pen or pencil properly, thick triangular pencils were introduced, as well as ordinary thin pencils with grooves where child's fingers fit well. PPPs also offered special pens made of anti-slip material that have been shaped to fit well the child's hand.

***Figure 2**: Grooves on the pencil surface make them easier to be held correctly with three fingers. Triangular shape is considered to be more natural to grasp.*

***Figure 3**: Special pens and rubber holders are offered for both right and left handers.*

The aids designed for easy drawing and writing are important for the child, as holding the pencil in a relaxed matter is one of the prerequisities for a smooth learning to write [1]. As drawing a figure and copying a written text makes part of the school readiness test, we felt that mentioning these aids contributes to the completeness of this text.

In a PPP, the child is provided with help not only in case there are some areas that need more attention and development to achieve the level appropriate for school, but also in case a serious problem is diagnosed, such as dysgraphia or dyslexia. In this case, a child usually attends regular sessions even after the start of the school attendance [12].

We should emphasize that at this point, we have visited three special educational institutions, and haven't seen any computer-based interactive aids for preschool children - we were only told that they existed. When we asked why they are not used in the institution, the answers were quite similar: the reason is money, and also the fact that such programs can only cover a part of what is necessary to teach the child before it goes to school [11, 12, 13].

After talking with special educators at different PPPs, we were recommended an institution where the computer-based aids were put to use: the PPP at Modřany. There we talked to a remedial teacher who clarified many ambiguities that we still had about the child-computer interaction. For instance, we were still uncertain about how do the children interact with the computer: on one hand, we learned that children spent an unhealthy amount of time looking at the screen [10, 11, 12, 13]; on the other hand, we still took the preschoolers into consideration, so how can they understand what is written onscreen while they can't read? We found out that it is common for children to make contact with a computer already at the age of three [13], and it is currently "the only device that guarantees to keep their interest and maintain concentration".

As to how do they understand the procedures necessary (e.g. what to write in the browser window in order to obtain image results for certain animal names and such), children are able to develop their own ways how to reach the goal. They perceive letters as images, and are very good at observing and imitating their parents or older siblings. According to [14], parents are quite often surprised at the amount of information their child acquired and/or remembered from a conversation or other activity their parents performed, thinking the child doesn't pay attention or is occupied by something more attractive than observation.

We were also interested in which graphic style works best for children, and we were shown the interactive spelling book presented so far as a revolutionary tool for dyslectics [16]. The graphics was considered "nice and moving, and children like moving things", but the overall impression from the program was bittersweet: "Yes, the graphics is nice.. but the nice graphics always means much extra time to load. Sometimes you just have to wait until all the animation takes place, which is, in my opinion, unnecessary." [13]

Another question we needed to be answered was the role of the parent. So far, we thought about the program we wanted to design as a guide for parents who will go through the educating process together with the child, explaining the goal and helping while necessary. We were told that parents are mostly bored while having to go through all the practice with the children, and are not willing to help much - their opinion is more like "an interactive application should be enough to teach the child by itself" [13]. So we finally agreed that there should be two modes: one with written assignment, in case a parent is willing to help; and another one, with recorded assignment, in case a child is left all alone with the program.

To find out where to start with the exercises that would fill our application, the remedial teacher recommended us [15], saying we should recast exercises from this book into an interactive program.

1.4 At the nursery school

We visited a nursery school in order to see how do they prepare children for school and which aids do they use. We talked to the directress.

The kindergarten didn't own any special interactive computer program; they didn't even have

a computer or television. According to what the directress said, "the children have enough of that stuff at home" [17]. She also claimed that the most important thing the children are supposed to learn in a nursery school is to live within a group of children of the same age, to play and share together and learn how to behave in such group under the authority of an educator. The directress emphasized the importance of "learning through playing", and explained that nursery school teachers were not supposed to teach children to recognize letters or even how to count objects, but admitted most children at the class preceding school were already able to count to 10. The educators at the nursery school were rather aiming to make children recognize the biggest and smallest object and the difference between a group of 4 balls and 8 balls than counting them. They were also playing games aiming to lead children to recognize different colors and materials.

Similarly to the teacher at the PPP, the directress observed that what needed to be practised the most was the orientation in space: children need to know what is below, above, on the right, on the left, at the top and at the bottom. Another part considered difficult for children was graphomotorics and fluent speech. The children thus practised telling a short story (according to a set of images or their favorite fairytale) and drawing (with both fingers and colored pencils) a lot. As a result, a child is able to tell its name, address and describe shortly its parents' occupations fluently, which is often required at the school enrolment [1, 5, 14].

When we asked about the graphic style of the interface the application should have, the directress explained that preschool children like to draw relatively big pictures and thus prefer them even to look at, finding them simple to understand. She suggested the illustrations of Czech artist Helena Zmatlíková as a reference (see Appendix 1).

1.5 At the school enrolment

Because the attendance at the nursery school is no longer compulsory, some children go there only during the last year before starting school or they don't attend kindergarten at all. This is why some schools, e.g. ZŠ Žernosecká at Prague 8, offer preparatory courses that take place once a week for 45 minutes. When we asked the directress at the school enrolment, she said that there are differences among children that attend a nursery school and those that don't, and this is actually the reason why they decided to introduce these preparatory courses. She claimed that the biggest difference consisted in the fact that children who don't attend nursery school need to acquire more communication skills and they are not so fluent while speaking. She also added that at the enrolment, the fluency of speech was examined and considered important, as it showed the level of maturity of the child. Another feature they looked into was the capacity to concentrate and to finish the task assigned.

While observing the room where parents with children were waiting before talking to the school staff, we saw that parents were filling up forms while children were given a picture and supposed to color it with crayons. This shows well how the concentration is checked: if a child is mature enough, it will focus on coloring until it is finished and the parent have filled the forms necessary. As there were more children at once sitting around the table and a lot of different kinds of colored pencils, some children started to interact immediately, asking their neighbor to lend them their crayon. The finished picture was taken to the room where the enrolment took place [18].

The preparatory courses organized by school were intended for children who were accepted to the 1st grade of the school. The classes focused mostly on getting the future classmates together, so that they get used to learn together, sit quietly during the period and maintain attentiveness. They also taught how to hold the pen or pencil properly and other habits necessary for a smooth start at school. No interactive aids are being used in these classes; however, the school works with an interactive blackboard already in the first grade, especially during mathematics and natural history classes [18].

The directress said they have suggested to postpone school attendance in case of only 6 children out of about 90 this year, and claimed it was even less than last year. However, they had to send one child back to kindergarten the previous year because "he was still too playful".

Chapter Two: Recommended activities and their convertibility into an application

According to [4], play is the most important activity in the life of preschool children. All the exercises and educational activities should thus always look like a game. In [1, 15, 20] the authors emphasize an individual approach and explain that a child's pace should be always defined by what it can do at the moment and what brings success and contentment to it. When a child is tired, thirsty or hungry, it is only natural for the results to drop. The achievements should be interpreted in the context of the situation and the child's capacity.

In the special brochures offered by PPPs [4, 19, 20] and preschool children-centered publications for parents [1, 5, 14, 15], the activities recommended are roughly divided into the following categories (according to which skills do they refine):

- drawing and motor activity
- visual perception and memory
- space perception and orientation
- time perception
- speech
- auditory perception and memory
- fundamental mathematical concepts
- social skills
- self-reliance in everyday life.

These activities are even accompanied by the necessary colored pictures in some of the publications [1,15] which make it very easy for parents (there's no need to look for other sources). Not all the publications cover all these areas, but they generally focus on the majority of these and provide many propositions of educational activities. We first focused on all of them, so that we can evaluate which are suited to be adapted into an application. At the beginning, we left out the social skills and self-reliance, as their very nature makes it extremely difficult to being adapted into a program.

The activities described can be performed by a child alone or by a child assisted by an adult (parent in the best case). Special publications and educators themselves strongly agree on the importance of the parent's presence at the childrens' efforts [1, 4, 5, 10, 11, 12, 13], emphasizing that it provides both motivation and appreciation by people who are, for the time being, the most important persons in the child's life.

2.1 Drawing and motor activity

A child should hold a pencil correctly with three fingers roughly at the age of three [1]. A relaxed, not constrained wrist is essential, as it makes it easier to learn to write [5]. Before starting to draw, children should first make circles in the air with bare hands to relax the wrist. If a child manifests difficulties with drawing, or doesn't like this activity, it is recommended to check whether the hold of the pencil is correct and doesn't tire the child unnecessarily.

According to [5], it is recommended to first let a child draw on large surfaces before moving to a standard paper (there have been cases of children who covered a whole wall with their drawings). Using a large wrapping paper let the child learn to keep his wrist relaxed, as it doesn't have to think about whether the drawing fits the designated space.

The shapes recommended are circles, halves of linden leaves (cursive letter "s"), serrated shapes ("saw"), wavy lines ("smoke"), screws and inclined lines ("rain") [20]. An important thing to learn is to make continuous line, when the pencil is touching the paper all along the shape. See an example on the picture below.

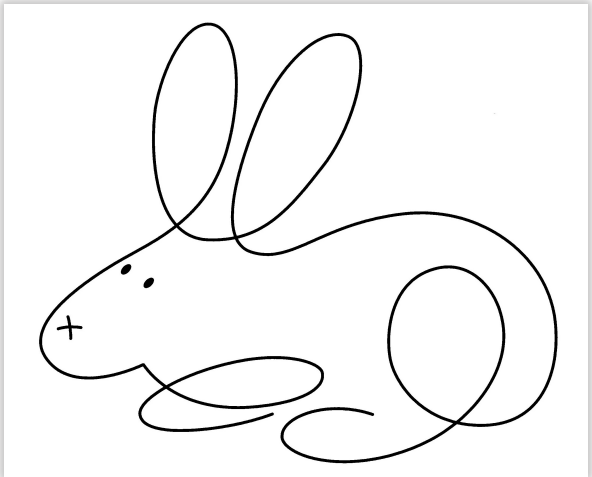


***Figure 4**: A picture of rabbit proposed in [1] representing an example of one-stroke-drawing. Child is supposed to trace the outline with a pencil. It teaches to follow certain line continuously, without interrupting the stroke. The accuracy of the line is not important.*

Drawing of the human figure should be given special attention, because the particularity of this drawing makes one of the criteria of judging the school maturity. Before reaching the age of six, children should draw characters with five fingers on each hand, incorporate throat, eyes and mouth and distinguish well all parts of the body (head, arms and legs attached at correct places) [1].

A good educational aid for preschool children are also coloring books [11]. When we asked in a bookstore, parents prefered to buy the ones with animals and familiar fairytale characters. An important attribute was the presence of a "template", showing to children which colors to use for particular shapes.

Children who draw well and like this activity usually don't have problems with learning to write [1]. On the other hand, it can also prove to be vice versa, so children who are still struggling with drawing should not be underestimated or misjudged when it comes to writing abilities.

Daily activities are also contributing to the development of the necessary fine motor skills. These activities embrace buttoning and unbuttoning a sweater, lacing up the shoestrings, threading beads or playing games based on mosaic making [20]. The child should also be encouraged while willing to help in the kitchen. Parents are often worried that letting a child help them with various housework can result into accidents and broken stuff, but they should also be aware of the fact that the child needs to practise in order to refine its skills, and thus provide it with enough manual activities [5].

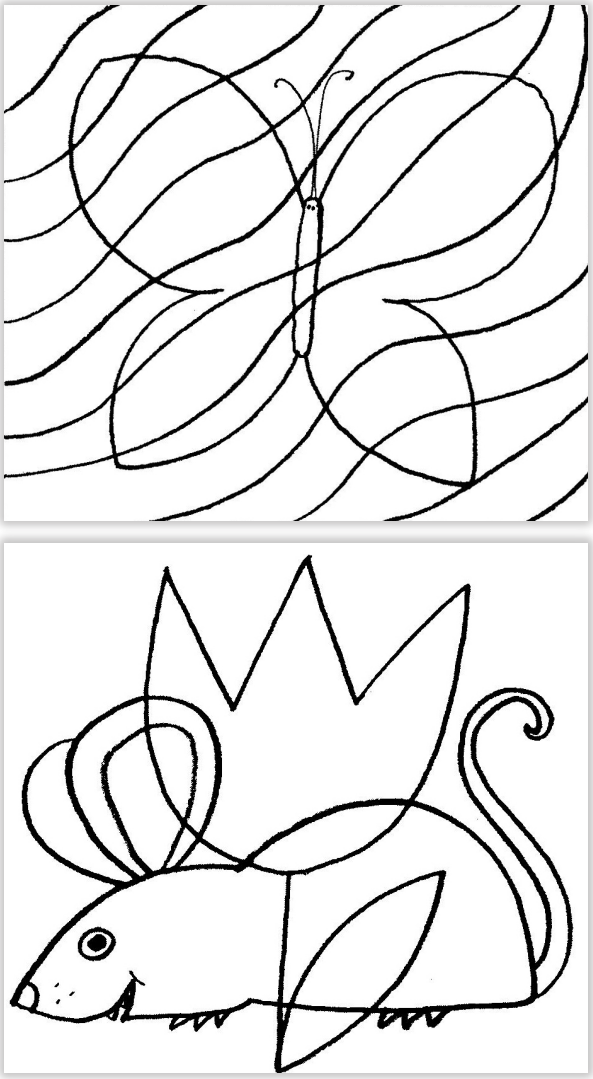
Among exercises focused on motor skills, there are many activities based on interaction with paper: for instance, tearing up color papers and creating collages, working with cutouts or creating simple origami [5, 20]. Working with modeling clay is also very developing, especially if the child tries to render objects at its disposition, such as apples or other fruits. Making contact with different materials and the employment of various techniques is very important, because it widens the child's general knowledge and refines its manual skills.

2.2 Visual perception and memory

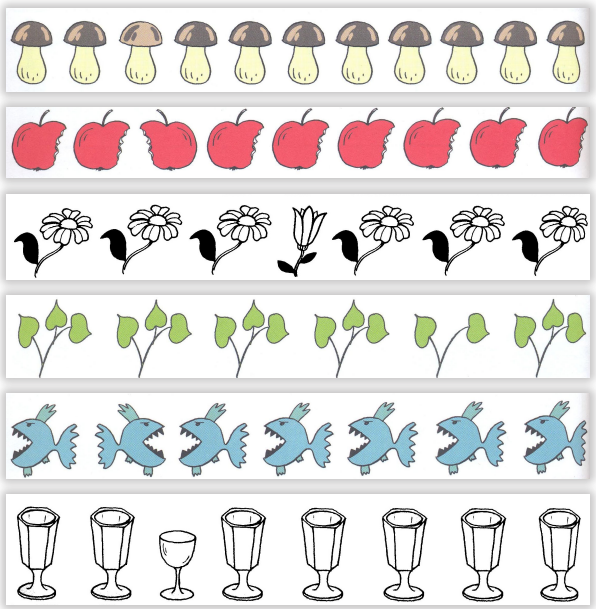
Vision is an important intermediary to get to know the world around us and gives us the most information about our surroundings [15]. The level of development of visual perception affects greatly both reading and writing [1]. In order to be able to read properly, it is important to develp the following [1]:

- distinguish figure from background
- distinguish details and positions of objects
- visual analysis and synthesis
- intentional ocular moves
- visual memory
- visual and motor coordination.

Distinguishing figure from background teaches to focus the attention on a particular object of interest. Determining the position of an object in space is crucial for a correct space orientation. Mastering visual analysis and synthesis helps to understand that the whole is made of parts and identifying them. Correct ocular moves and visual and motor coordination are particularly important while reading, to ensure the correct movement on the line (left to right) and on the whole page (up to down). The ability to remember objects perceived is directly influencing the ability to learn at school. See the figures below.



***Figures 5 and 6**: Pictures teaching distinguishing the figure from the background [15].*



***Figures 7 to 12**: Pictures teaching distinguishing the different object in a row ("What doesn't belong there?") and finding the mirrored object [15].*

Puzzles (or simply images cut to separate pieces) that children assemble together are also considered beneficial [1, 15].

2.3 Space perception and orientation

Correct space perception is a necessity in the everyday life [1]. Familiarity with concepts such as the first and the last represents the basics of fundamental mathematical skills. These terms are also closely related to the time perception, which we will discuss later.

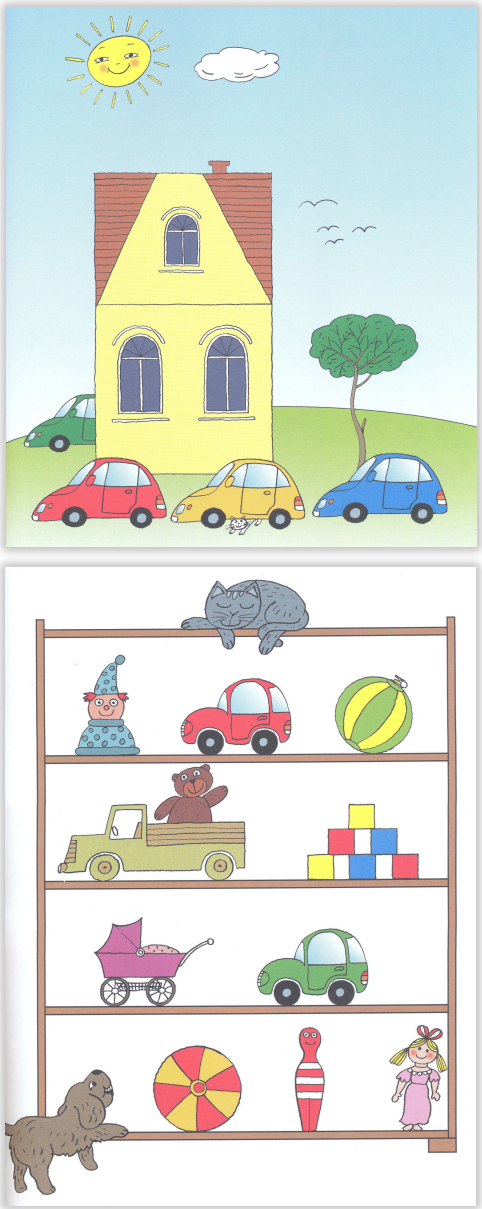
Children who have difficulties with the space orientation might experience problems with the orientation in a text (while both writing and reading) and can be also put at disadvantage at manual work [1, 15].

Educational activities aimed at the space perception embrace games that make children name the position of a certain object, or place it correctly on the designated space ("Where is the apple? What is at the left hand side of the plush rabbit?"). Orientation in space can be refined even outdoors on a walk, when a child listens to the parent who describes which moves are made ("Now we turn left, go straight ahead a bit, turn right at the big house and then we arrive at the nursery school") [15].

The terms "right" and "left" can be also practised on the child's own body: it should be able to point to the right eye or to the left hand [15].

The notion of space includes not only the orientation within an area using three axis, but also the comparison of the objects' sizes: what is bigger, what is smaller and which objects are equal. According to [17], the comparison of objects in terms of size and quantity is one of the areas that need to be given special attention, as they seem to be difficult to master.

To teach the space perception and orientation, images in special publications such as [1, 15] can be used, but even regular books for children with clear colored pictures can provide a good educational aid. Space orientation centered educational activities can take place in an area the child is familiar with as well (such as its room with known objects like toys). See the pictures below for examples.



***Figures 13 and 14**: The upper image provides reference for practising prepositions such as in front of, behind, above, underneath and between; the image at the bottom is good for showing what is up and down [15].*

2.4 Time perception

Preschool children develop the time perception very slowly. They live mainly in the present, and their time awareness is distorted, depending primarily on the action that is taking place [15].

As children get older, they can understand better the cause and the consequence, and thus grasp better the situation resulting from the preceding events [15]. The correct understanding of time sequence is helpful later in mathematics, when numeral sets come to question.

To develop the time perception, children should be aware of actions that are characteristic for morning, noon and evening and also know when some specific actions take place in the context of a whole week (for instance, a drawing course on Wednesday) [1, 15].

Another good exercise is to let the child name individually which activities are typical for spring, summer, autumn and winter and make sure it understand in which order the seasons alternate. In the nursery school, children are likely to draw a tree in spring (in full bloom), in summer (with green leaves), in fall (with yellow and brown falling leaves) and in winter (without leaves).

Special publications offer reference images even for this kind of exercises; see the examples below.

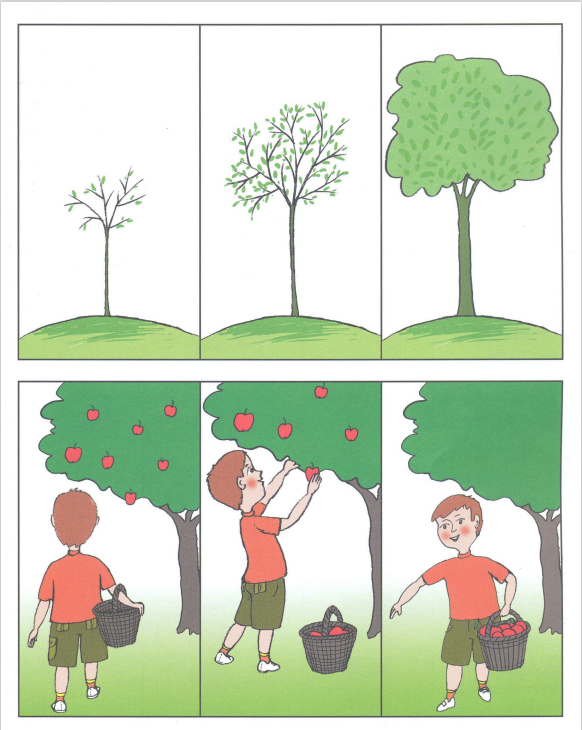


***Figure 15**: Picture showing two exercises focusing on the time perception: the triplets are supposed to be cut out and children should arrange them correctly [1].*

2.5 Speech

Mastering speech and the correct pronunciation is important not only while learning to read, but also for writing, as children tend to write words as they pronounce them [4].

The development of speech depends on visual perception a lot (first, the child sees an object and associates it with a word; later, the object is recalled based on the word) [1].

A simple recommendation is thus to let the child speak enough. It can tell a short story based on the images in a picture book or talk about what can be seen through the window. Nursery rhymes help to develop the sense of rhythm, and they can be accompanied with clapping hands, which makes it easier to understand the rhythmicity [5, 19].

The vocabulary of a child should be appropriate to the everyday life: parents should contemplate whether their child understands what they are saying and help with widening its vocabulary.

First, children can try to create synonyms with visual aid, and then even without the pictures; they should also be able to define purposes of certain familiar objects ("What is a train?") [1].

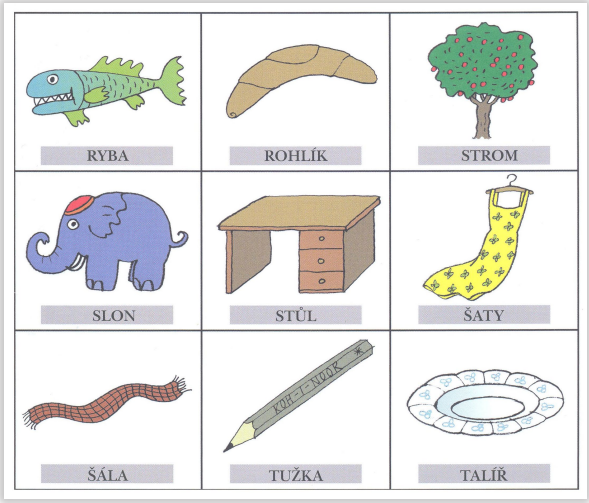
Creating generic terms is also a good exercise, as it helps the child to look at the objects from a more complex point of view and grasp the relations between them ("Tomatoes, cucumber and pepper are all..." - "Vegetables."). These activities can be done both with visual aids and without them; at the beginning, letting the child see the real objects is a good idea.

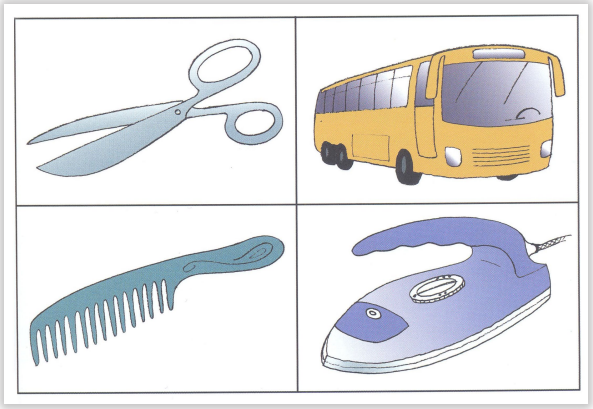
Speech developing exercises are various, based on which area of speech needs special attention [15]. See the pictures on the next page. If a child manifests problems with certain specific sounds, it is best to take it to a speech therapist who will recommend appropriate voice exercises.

The deficiency in speech can be caused by various issues that are not directly connected (including social environment), and it is also influencing other areas (the speech is one of the manifestations of the intellect level) [15]. The correct development of speech should be thus given special attention.

2.6 Auditory perception and memory

Similarly to a foreign language learning, the most important practice for a child is to listen to other people talking in an environment that is not oversaturated with noise or other disturbing sounds.





***Figures 16 and 17**: Looking at the upper image, the child should name the objects in boxes. Note that the titles are printed below. On the Figure 17, children are supposed to point at an object depending on its purpose ("What do we use for ...?") [15].*

In the school environment, most information is acquired via the hearing. Children need to capture, process and keep the instructions in memory, so that they remember what is necessary to do first and how to proceed with homework for instance [1].

At some point, we can compare the auditory perception to the visual one [1]: while listening to a certain person, we ignore the noise from outside and concentrate only on the discussion; it is the same with the perception of figure and background (see the Visual perception and memory section). Children thus need to learn to concentrate and omit the irrelevant sounds from the outside.

Auditory perception centered activities always require a presence of another person that helps the child with the set up, listens and help with difficulties or correct imperfections. These activities embrace listening to a longer story, learning nursery rhymes by heart, recognizing the number of words in a phrase, recognizing the nature and direction of a certain sound and many more [1, 4, 5, 15, 19, 20]. See the images opposite.

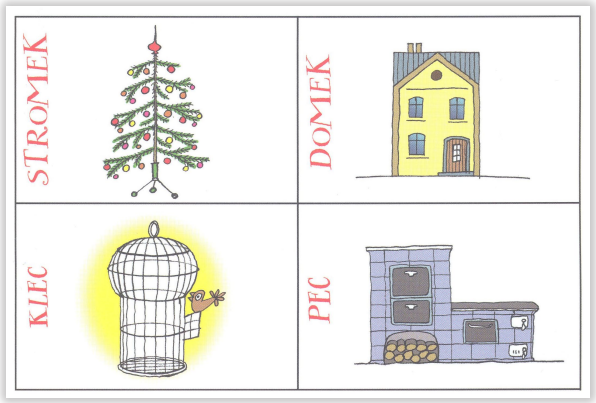


***Figure 18**: Children are supposed to recognize pairs of objects whose titles rhyme [1]. Again, note that the titles are printed, so that the child can start recognizing letters.*

***Figure 19**: The image above let the children see objects whose titles sounds similarly, but one letter always differ. Children are supposed to identify these letters [15].*

2.7 Fundamental mathematical concepts

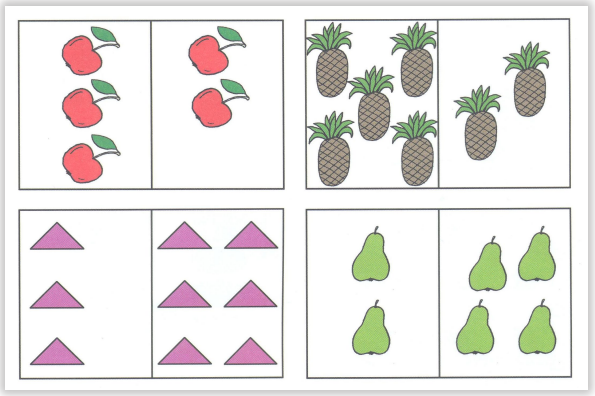
Activities focused on fundamental mathematical concepts are supporting the progress of logical thinking. It is important to give the child enough time to finish the exercises by itself, because the outcome (and the process) is much more important than the speed of the completion [20].

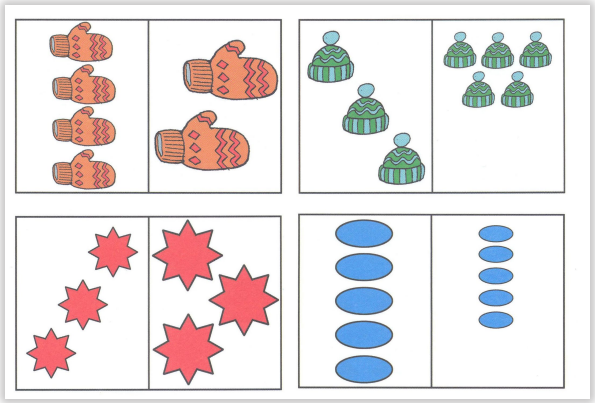
Before starting to work on exercises with pictures, a preschool child should manipulate with various objects at hand directly: the touch helps the child to perceive the size, amount, weight and shape better [1].

Mathematical concepts require the development of many other areas as well: the space perception is important for geometry and a developed visual perception is needed so that the child understands what is the whole and which parts contribute to its form. The development of mathematical concepts needs also an appropriate level of speech, so that the child understands terms such as sorting and classification. Later on, the abstract thinking needs to be established [1].

Activities that develop fundamental math-

ematical concepts include comparing amounts of objects (putting three cubes in front of a child and let him put the same amount beside), sorting items according to their sizes and purpose, selecting the biggest, smallest and medium-sized item, or even recognizing the element that doesn't fit in the row [1]. See the pictures below.





***Figures 20 and 21**: The image above shows a simple comparison exercise: where are more objects, on the left or on the right? The figure below shows a more complicated variant, where the objects differ in size [1].*

2.8 Interactive aids

Besides educational activities described in special publications, parents can make use of some Internet resources, such as [21]. Besides many suggestions of both indoor and outdoor activities, there is also a lot of resources for arts and crafts such as pictures ready to be printed and colored. There are also online games available, such as finding pairs of the same animals or practicing the eye coordination. These games are interactive and fit well the needs of preschool children.

Concerning computer-based interactive aids for preschoolers, there are especially programs created by ABC vzdělávání [22] that were mentioned by most specialists we talked to. These offer help with school subjects such as mathematics or english as well as applications for preschool children focusing on various fields. See the list below:

- Alík: Než půjdu do školy (set of simple educational games)
- Alík: Pojď si hrát (contains interactive games from different areas such as music or fashion)
- Chytré dítě - Pro nejmenší (introduces first interaction child-computer)
- Lískulka - Ty a počítač (includes games, songs and even a text editor for children)
- TS Dětský Koutek 1-5 (contains educational games from various fields)
- Všeználek to ví (educational games focusing on mathematics, language and other fields)
- Klubíčko her (includes animated pairs and other games for preschool children).

However, only two applications out of these focus directly on the educational games. Almost everyone we talked to [10, 11, 12, 13] knew that some interactive educational applications existed, but only one special educator had such an aid in possession and use ("I hope it will work so that I can show it to you. Sometimes I just can't get it to work."); it was the interactive spelling book [16]. The reason why specialists aren't working with computer programs more is, as we have already mentioned, that they find them expensive or even counter productive, as children pass most of their time watching television or playing computer games.

That's why the interactive aids offered in some PPPs are all physical: children can touch them, manipulate them directly and are given an immediate feedback (such as a change of state that is clearly visible). Besides an immediate, clear feedback, the interactive tools have another important asset: they are usually very simple and easy to use. Most of the time, they are designed to be put into different states which are reversible [12].

We were shown these interactive aids at the PPP for Prague 1, 2 and 4, during an interview with the author of special publications referenced in this work, PaedDr. Drahomíra Jucovičová. She works in this PPP as special educator and is the author of most interactive aids that will be mentioned below.

During the interview, we learned that the best way to teach a child is to appeal to more than just one sense at the time: for instance, if a child needs to remember a shape (of a letter for instance), it is always better to make him model it out of modeling clay or a piece of cord than just show it printed on paper. Outlining the form with a finger works as well; it is also possible to be even more creative and use a shallow bowl with sand or other powdery

material that stands for "writing paper", and let the child use its fingers to draw the letters. Putting the pen and paper aside makes the child much more relaxed [12] and teaching then resembles a sort of play. Another example of using very simple material as an interactive tool is to cover a relief-paper (plastic film onto which shapes such as animal outlines have been imprinted) with sand and then let the child "find" the animals.

Such tools can be used even after the start of school, as they help the children to remember important rules such as where to write a "y". We were told that seeing the word written, as well as seeing the picture representing it, together with being able to touch the relief-paper help the child to remember the rule in a much easier way [12]. See the picture below.

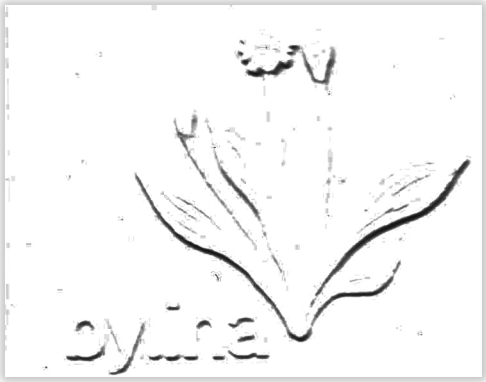


***Figure 22**: Plastic film with imprinted outline of a flower and the appropriate word. Children can color the picture and remember the word better thanks to the possibility of touching the relief.*

There is an inexhaustible quantity of similar interactive tools that can help children learn how to distinguish shapes or help to remember outlines. Some of the interactive aids offered were simply focused on developing fine motor skills; for instance, sticking paper flower on a stick into colored polystyrene can "simulate" gardening, but can be also used while polishing fundamental mathematical skills ("Put two blue and three red flowers on the flowerbed.") [12].

2.9 The convertibility of the aids mentioned

We reviewed educational aids from seven different fields (drawing and motor activity; visual perception and memory; space perception and orientation; time perception; speech; auditory perception and memory; and fundamental mathematical concepts). However, we found out that not all of them are well convertible into an application. The nature alone of some areas that need to be developed is making it very difficult (or even impossible) to transform them effectively (for instance, auditory perception: the device cannot simulate sound coming from different directions unless a spatial sound system is in use); another time the control mechanism would be too complex to implement correctly (for instance, speech based activities that would require recording the child's voice and comparing it to some reference recording). This might not be impossible, but it seems that some activities are simply better to be done with family members who provide immediate and more appropriate feedback [12, 13].

On the other hand, there are a lot of activities that could be much more useful for a child if they were in a form of an interactive application than just printed on paper - especially the ones from the visual perception area (for instance, intentional ocular moves centered activities can be based on observing an animated objects on screen and responding with a click if some condition is satisfied).

Other well-convertible educational activities can be based on space perception (finding and labeling objects in the designated area) and orientation, time perception (putting images in the correct order by dragging them) and even fundamental mathematical concepts (selecting the group that contains more objects than the other one). In case the device in use is a touch screen one (such as a tablet or iPad), even fine motor skills can be practiced: Figure 4 could appear onscreen and the child would outline its contours with a finger. Such activity is close to working with physical interactive aids such as the bowl with sand in which children draw the outlines of letters (see the previous section).

Considering the research nature of this work, educational activities recommended in special publications and the suggestions of educators we talked to, we decided to design a prototype with several educational activities from the following fields:

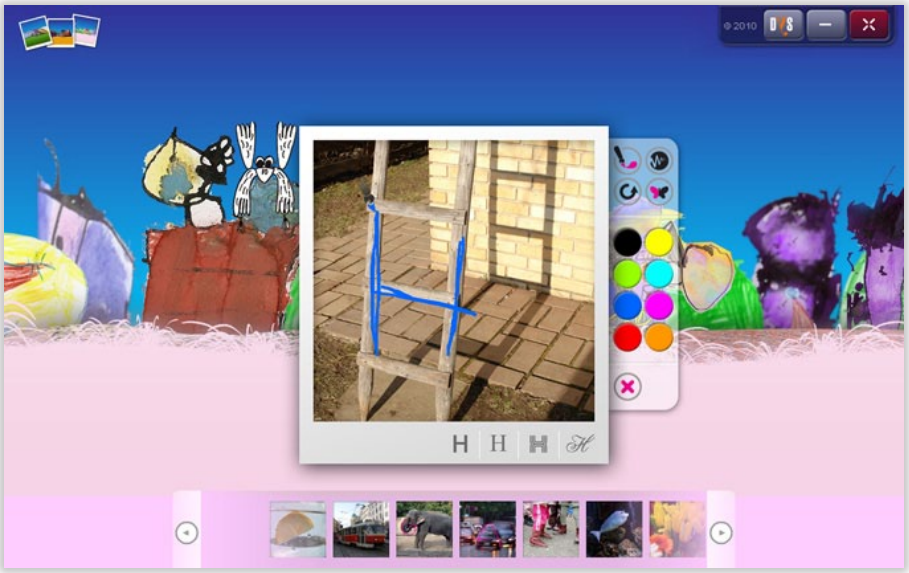
- visual perception and memory
- space perception and orientation
- time perception
- fundamental mathematical concepts.

Creating several simple activities should allow us to test the interface of the application as well as verify the success rate of the convertibility of educational exercises into a program.

See the content of the enclosed CD for the prototype incorporating activities from the four fields mentioned above.

***Figure 23**: A screenshot of successfully finished pairs game [21].*
The game starts with two pairs and gets more difficult if the previous one is finished quickly and properly (extra pairs with new animals are added). If a child completes successfully the game with nine pairs, the inscription "well done!" appears on screen.
We will discuss the look and feel of an application for children in Part II of this work.

***Figures 24 and 25**: Screenshots of the interactive spelling book [16]. Children are supposed to help two hedgehogs find all the alphabet's letters, which appear all around them in form of everyday objecs. For instance, "H" looks like a part of a ladder. As children outline the letters' contours with colors, they are supposed to learn and remember their shapes better.*



Chapter Three:
Design outputs and the research summary

Following the recommendations of [6], we talked to people who work with the target group (preschool children) and found out which activities are recommended (see the previous chapter). Based on the information we obtained during the interviews and the nature of the output media, we identified areas we need to focus on (see the previous section).

Besides information concerning the content and nature of the application, we were very interested in the desired look and feel: how should the interface of our interactive aid look like? And how do we present the control of an application intended for children?

3.1 Design outputs summary

The main problem we had to face was the fact that special educators seldom had existing interactive tools in possession and thus had little experience concerning how children react to them. In the nursery school, we learnt that children prefer larger, clear images - which is supported by the style of illustrations in special publications such as [1, 15], but seems to be in opposition with the most up to date interactive aid, the spelling book for dyslectics (see the screenshots on the left).

It appears though that cartoon (hand-drawn) interface appears friendlier to the kids than photos, because the photograph is full of details that may be unnecessary at the moment and can cause distraction or loss of concentration due to the cognitive overload. When we asked about the issues related to the fact that cartoon images can appear "too simplified" and even show "an altered reality", we were told that children are so far confronted *especially* with such altered reality - for instance fairy tales and fables. Even specialized publications such as [15] show situations that are not common in real life: for instance, when focusing on teaching the ordinal numbers, there is a picture of animals making queue in front of an ice-cream shop. The level of detail and style of the illustrations is discussed into more detail in Part II.

As we have already stated in the first chapter, children like colorful, moving things [13] that guarantee to catch their attention, and thus the application should contain enough animations. On the other hand, these should not slow the application down by taking too much time to load [13].

At the end, we were not able to gain enough information concerning the visual and interaction design of the application while talking with special educators, and decided to continue the research, this time focused solely on the children-centered design. Due to its nature, this part of the research is covered in Part II of this work.

In general, we can't expect that making an educational application would solve all the issues and provide the children with something like a complete preschool course. Special educators and professional publications agree that real-world based experience can never be replaced with mere pictures or simulations [1, 4, 5, 10, 11, 12, 13, 14]: nothing can replace the direct experience itself. Showing a picture of zebra to a child can make it happy or interested, but taking the child to the zoo and let it see the animal alive are completely incomparable experiences. Even though nowadays children are provided with many expensive, complicated toys and interactive applications, the real-world experience can never be replaced and should accompany as many educational activities as possible. The fact that a child can take some objects in its hands, touch them and then sort them according to some guideline is an experience much more valuable and educational than letting the child sort only pictures of the objects in question.

The application we design should thus be perceived as a complementary tool that helps children develop their school readiness by completing educational activities at home.

3.2 Research summary

During the research, we were able to gain many important insights into the school readiness problems. These provided much clearer vision of the application that is needed than we initially had. We learnt that making a general application for children with issues concerning education is a very subtle ask that needs careful and complex cooperation between psychologists, educators, interface designers and software developers [13].

Each child that evinces problems in every-

day life, while playing with others or participating at some educational activities, needs to be examined by a specialist who then determines where the problem resides and which path needs to be taken to solve it. It is thus impossible to make an application that would suit all the children at all times and cover all the areas a child should be conscious of before entering the school grounds.

Even though we wanted to focus on preschool children who manifest difficulties with completing tasks a school-ready child should be able to do, it is impossible to cover all of them (there is a need of an immediate feedback of the parent or educator, the need of physical manipulation with objects, and also limits of the device the application runs on; see the "Convertibility of the aids mentioned" section).

As we decided to cover several exercises that are proposed in [1, 15] or activities based on them, we can be sure that the exercises are designed well and comply with requirements set by psychologists and special educators.

We are also limited by the hardware and the nature of the output media set by the assignment: television and set-top box. However, as we will see in Chapter Three of Part II, these devices are not as restricting as they might seem at the first sight, and can even provide children with the acquisition of some valuable skills.

To summarize all the information we gathered concerning the purpose of the application and its functionality, we can say that the application needs to be:

- meaningful in terms of the content (the exercises)
- usable by children in terms of the interaction design (controls such as buttons and navigation)
- acceptable in terms of visual design (the look and feel should please children).

According to the main cycle of work that should be followed while taking the user-centered design process into consideration [23], we fulfilled the first two steps:

- specify the context of use: identify the people who will use the product, what they will use it for, and under what conditions they will use it:

We are designing for preschool children, including those who haven't been accepted at the school enrolment according to the common schedule. These children will use the product in case they need to improve their school readiness in the field of visual perception, memory, space and time orientation and basic mathematical skills. They can also use the application while seeking another game-like activity that can help them pass the time and teach them something new and beneficial at the same time.

It can't be expected (though we would highly recommend it) that the children will be helped with the control of the application or the activities themselves, so all the instructions must be presented in a clear, simple way that even the preschool children who can't read yet would understand. The best way to achive this seems to be the use of the sound: a voice should read the asignment of the activities aloud [13]. For instance, the interactive spelling book is "talking" to the children all the time, providing an immediate feedback.

- specify requirements: identify any business requirements or user goals that must be met for the product to be successful:

The application has to be extremely easy to use, and meet the design standards acceptable for preschool children. The look and feel need to ensure that children will perceive the application in a positive way. We should thus use pleasant colors approved by children, images that are both easy to understand and nice to look at and a navigation that doesn't presume the user is familiar with the basic conventions - although specialists agree that most children have developed their own ways how to interact with relatively complex electronic devices.

The design requirements will be discussed into more details in Part II, where we try to find and outline the principles of design for children. The remaining two steps of the user-centered design cycle, Create design solutions and Evaluate designs, will be covered in Part II and Part III respectively.

Part II: Design

Chapter One: Designing for children

Designing for children seems to be a very complex task, especially because there are still no unshakable standards in terms of visual language and conventions [24, 25]. However, there are few resources concerning designing for children in terms of websites, and also papers covering projects where children tested various interfaces or took part directly in the designing process itself. We try to put all these global fragments together with the information we gained from the specialists we talked to and suggest a design that would comply with both.

However, the scope of the literature available was narrowed by the instructions we had set in the beginning, such as designing for a specific group of children (preschool). This constraint needs to be kept in mind all the time, because these children are very young and most of them don't understand interface control conventions and other signs commonly used in everyday design that most people identify thanks to their own experience. Some of the children we design for can read already, while some can recognize a few letters only, and we expect that most of those children can't read yet. This means we should not rely on inscriptions when it comes to conveying information: the interface shouldn't be textual only. This aspect is also supported by the fact that young children like gaining information from more than just one-sense-centered source [4, 5] and the interface should thus let the children use as many different senses as possible. This measure also positively affects attention.

Moreover, the gap between children from different age groups seems immense [26]: for instance, a six years old boy claimed that certain website was intended for "babies, maybe four or five years old". If we can think that children can be approached as one group, we are wrong: the children are well aware of the age differences between them, as they perceive one year in their life as a long time.

While designing an educational application for preschool children, we also had to remember that children are extremely critical and have no patience [25]. They need a quick feedback and often click more than once, challenging the interfaces they use and manifesting the need for intelligent systems. The design part of the process is thus very important: children look for fun, games and entertainment - they are not using some application because they need to get some work done as the adults. If children don't like the look or the way of interacting with the application, we can't expect them to return and use it again; they will simply leave and never open it again. The beauty and attractiveness play important roles in design in general [27] and there are also studies that justified the childish look of cartoon characters intended for children's viewing. We will discuss this later while focusing on the graphic design.

1.1 The design process workflow

As we have already observed in the previous chapter, we discovered that the visual design of some interactive applications is not always in accordance with what educators and specialists recommend (for instance, compare Figures 13 and 25). As there are currently only a few resources seriously focusing on the visual design intended for children [33], its principles and guidelines, we feel that this field deserves our attention in particular.

Considering contemporary media that concentrate on children, we often see a very large scope of totally different designs (see the pictures below and Appendix 1 for more reference images).

***Figure 26**: Beatrix Potter's Peter Rabbit provides an example of a realistic approach to the children-centered illustration. The liking of this character is supported also by his personification (Peter wears a jacket).*

***Figure 27**: Zdeněk Miler's Krteček. Illustrations with clear shapes, carefully harmonized colors and simple, yet charming animal characters made the novel series known worldwide.*

Fairy tales include simplified, hand-drawn characters with physiques that amplify their natures and are often exaggerated; on the other hand, there are tales about animals that include nearly exact, natural-history-book-like illustrations.

In this part, we would like to find out which graphic style suits children's needs the best when used in an educational application, and what sort of interaction feels easy and comfortable for children. We use the information gathered from papers, websites and special publications to create first sketches and designs which are then evaluated by both children and educators (see Part III of this thesis for more information about evaluations and testing).

The main reason why we decided to concentrate on the visual aspect of the application as much as possible is that we feel it offers a large space for research - the ambiguity of current designs suggests that there are still a lot of questions to be answered and a lot of challenges to be taken. However, we have to anticipate that the outcome of this work might only expose more questions and provide only a blurred vision of the results we hoped for. We should also consider the fact that children and their expectations and preferences are changing at an enormous pace, developing according to the technological progress and discoveries. We hope though that this thesis can provide a plain set of rough principles that can reveal a bit of the contemporary preschool generation visual preferences.

To comply with the iterative design process supported by [34], we struggled to consult our visuals *by parts*: as soon as some part of the interface - design of some characters, one of the storylines, an idea on the interaction - is finished, we ask an adequate person (or persons) to provide us with feedback on it. Such approach is beneficial to the design, because it allows us to move the final design constantly closer to the users' needs. Consulting smaller parts gradually helps us to prevent repeating mistakes, and the feedback we get on one part can be used as a hint or even reference for the upcoming one. The problem of this approach is that we constantly need specialists or children themselves to evaluate our drafts, which can be really complicated considering our target group. On the other hand, with contemporary options offered by the social networks, we can get a quick, immediate feedback remotely that can help us a lot (as long as it comes from a trusted source).

Such quick feedback pays off especially if we evaluate some completely new idea that is not firmly supported by publications or papers, or in case we need to test a crucial idea that will be developed further and should have solid base.

In the following chapters, we will thus describe the whole design process, from the early sketches to the creation of the interface.

Chapter Two: Graphic design

In this chapter, we will focus on graphic look of the interface, its colors and fonts we should use. Even though the interface is not going to be textual only as most applications today and the information that needs to be conveyed is not relying on the inscriptions, we cannot omit the writings completely. The inspiration and references were taken not only from papers describing researches conducted worldwide and reliable design principles, but also from children's books, series and other materials intended for them.

2.1 Colors for children

"Color plays a vitally important role in the world in which we live. Color can sway thinking, change actions, and cause reactions. It can irritate or soothe your eyes, raise your blood pressure or suppress your appetite. When used in the right ways, color can even save on energy consumption" [28].

The colors choice influences greatly the overall impression we have on objects we interact with in the everyday life. Marketing researchers constantly seek which colors please the customers and help promote certain products better, and companies put much effort to choose the "right" colors for their logo. Colors have their own meaning which can vary greatly from culture to culture (for instance, white is the colour of mourning in Asia, and brides thus tend to wear red or pink), and our own perception of colors change as we age: for instance, we tend to prefer bright colors in childhood and darker, dim tones at the old age [29].

According to [29] and [30], this phenomenon has several possible explanations which are likely to be mixed together:

- children are partially color blind: they may be inclined to prefer bright colors because the rods and cones in their eyes have not fully developed, and thus children's eyes may not be adapted to see dull, dim colors very well or even at all
- a preference for bright colors may be a result of evolutionary developments: fruits and vegetables are bright, bold colors when they are ripe and inviting to be consumed, but they turn grey, brownish or even black as they begin to rot. Poisonous, dangerous insects or snakes often feature bands of bright colors, both scaring ennemies and discouraging others to touch them. Sticky notes we use to put down important things we should not forget are made of bright colored paper, so that they grab our attention
- bright colors are usually associated with fun, happy time by the adults, which explains why do they tend to give children multicoloured things, paint their rooms bright colours and buying them colourful books and cartoons. As the children live in an environment full of saturated colours, they get comfortable with them and start associating them with pleasant memories.

It can thus be summarized that the preference for bright colors is the result of the combination of both learned and biological behaviors (see Figures 28 and 29).

***Figure 28**: Fresh ripe raspberries are bright reddish hue, which many people associate with a good-tasting sensation [28].*

According to [32], the colors that please children the most are purple and yellow. Almost 75 percent of pre-adolescent children prefer purple to all other colors, and bright purple can be thus used for the promotion of children's products. Yellow is the color

of sunshine associated with joy, happiness and energy, and works well for children's products and leisure goods. Yellow is also the color that remains well visible even under dimmer conditions, and guarantees to catch people's attention faster than any other color [28]. Most of the people filling up the survey on [28] associated yellow color with happiness.

***Figure 29**: Photograph of a toy shop. Notice the abundance of bright bold colors and light, which suggest a friendly, joyful atmosphere [31].*

The colors used in design are crucial for both aesthetics and usability, and their choice in a design intended for children is even more important. Because we are going to create an application children would like to use, we need to create a design pleasant to their eyes. A pleasant visual experience is achieved by the color harmony, which suggests a balance and inner oder as well as engaging the viewer [28].

Colors now posses not only cultural specifics and symbolic associations, but are often perceived in a very personal way [35]. Color can be used both as a language and as a system of signs that has the potential of creating an emotional response. Below we include some findings that we found necessary for the right color choice in case of the children-centered application [35]:

- high color intensities are dynamic and create a feeling of movement
- the color of a symbol enhances the information it conveys
- the color of an object is seen before its shape and details
- color helps to categorize information
- red spectrum contains advancing colors
- blue spectrum embraces receding colors
- complementary colors (see the color wheel opposite) of equal lightness and high saturation tend to make each other appear more brilliant
- blue-greens appear lighter, whereas reds look stronger and therefore heavier
- color has a dramatic effect on legibility, both for texts and images.

Choosing the right shades and hues in accordance with the color theory is a complex task and describing all the findings exceeds the scope of this text. To achieve a pleasant visual experience, we rely on the basic principles of the color wheel (see the picture below) and swatches created by people with the appropriate knowledge.

***Figure 30**: The color wheel. Complementary colors that lie opposite each other are associated with contrast, whereas analogous colors lie adjacent to each other and result in harmony [35].*

There are also reliable online stocks of swatches, for instance the kuler website by Adobe [36] which allows the download of an immense amount of 5-colors-swatches directly in the format of Adobe Illustrator swatch file (.ase). Swatches are named according to the mood or objects they stand for, which makes it very easy to find the right shades really quickly. There is a large stock of swatches connected to children, such as "childrens nursery". See Figure 31 on the opposite page.

Besides the references mentioned above, we can also get inspiration from illustrations inside children's books that evoke pleasant impressions (see Appendix 1 for examples).

To sum up, we should use interesting, bright colors in the interface, because children like them better; we should be careful about the combinations though and take care to harmonize the hues to create a pleasant visual experience. Too bright colors on large areas can be distracting, as the eyes are constantly attracted to them. We should also avoid using too much bright colors on one picture,

and employ them in a functional way - for instance, bright colors can act as a tool that guides the children's attention.

On Figure 33 (on the page 28), it is possible to see illustrations of characters we used in the interface together with comments explaining our choice of the colors.

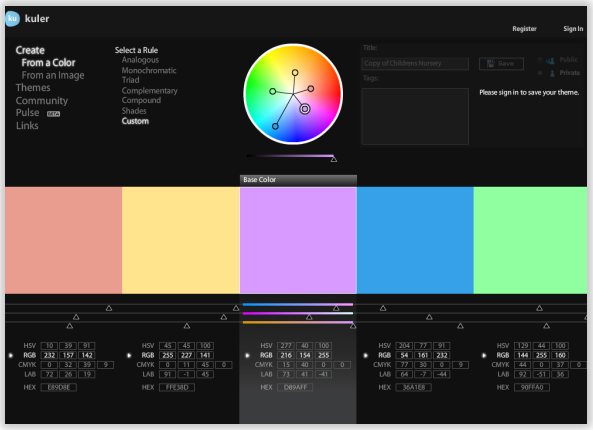


***Figure 31**: Screenshot of a swatch available at the kuler website. Besides the .ase file, all the colors used are described in HSV, RGB, CMYK, LAB and hexadecimal code. Kuler also shows them on the color wheel. We chose this swatch to be used in our application because the hues represent all the colors of the wheel and their tones create harmony.*

2.2 Appropriate fonts

As special educators suggested [12, 13], the application should be available in two modes: one with a pre-recorded sound that reads the instructions, and another one with instructions printed on the screen, so that it can be used when a parent is assisting the child in the educational process.

Concerning the font we wanted to use in our application, it seemed natural that it should comply with requirements such as being well legible, and its size needs to be big enough. The legibility and overall simplicity, together with an appropriate size of the font are desirable for the sake of both children and parents: children might enthusiastically recognize some of the letters, while parents would have no difficulties reading the big legible letters on the television.

To meet these requirements, it was decided to use a font from the sans-serif family, which is better for readability [35]. We can nowadays choose from a wide range of different typefaces; however, we looked for a really simple one. Even though children might appreciate playful, outlandish fonts that they perceive more like images than letters, our primary goal was to convey information - and secondary help children recognize familiar shapes (only in case they want, there is no initiative to make children read the instructions for themselves).

After a careful selection, we decided that the font we should use in our application could be `osifont` (never capitalized). One of its assets is the fact that it is available with all the Czech diacritics. osifont's fine legibility and clear simplicity can be seen well in comparison with Adobe Garamond Pro, a serif font we used when writing this thesis. We also opted for the use of capitals, as children are usually able to recognize them sooner than lower case. See Figure 33 for examples of this font's capitals in use.

2.3 Vector graphics

As the directress of the nursery school suggested, we immersed into books for young children and searched for a style that would be attractive for them, yet still simple enough to animate and use as the main visual fashion of the program. Directress' preferred illustrations were those by Helena Zmatlíková (see Appendix 1), which resemble carefully worked-out colouring book: there are thick black borders indicating shapes filled with vivid colors. The style is simple, without many details, but the information needed is conveyed in an effective, children-friendly way. Helena Zmatlíková provided illustrations for countless books designated for children, including short stories meant as the first reading experience.

Similar style, featuring bright colors and black outlines can be observed in artworks created by Zdeněk Miler (see Figure 27 or Appendix 1) and Jaromír Zápal (see Appendix 1), and the use of black outline can be found even in illustrations by Jiří Trnka (see Appendix 1) and Beatrix Potter (see Figure 26), who we have already mentioned in the previous chapter. All these artist significantly influenced the world of Czech illustration meant for children.

Considering the need of creating simple, moving graphics, and the popularity of subtle, distinctively outlined shapes lead us to the idea of employing vector graphics. Vector graphics artworks are made up of different shapes, such as curves, points, circles and lines. Thanks to paths (also called "vectors") with anchor points and Bézier curves that define the artwork, vector graphics is resolution independent, as it can be scaled at will while maintaining the highest quality.

Creating artworks using vector graphics can result into precisely drawn shapes that are re-

quired in logo design, billboard design or even cartoon art. Simply designed vector characters with a cartoon look seemed suitable for our purposes, as animating them means changing shapes and their positions - which is much simpler in case of vector graphics than in case of bitmaps. It can also prove to be difficult to achieve precise shapes using bitmap, hand-drawn graphics only: in case of vectors, simple shapes are the fundamental building blocks that are available in every vector graphics centered software.

Another reason to choose vector graphics was that it looks "discontinuous" by nature: using black outlined shapes "admits" that the artwork is made of several separate elements. These elements can then be animated separately in a very simple way, because the nature of the artwork doesn't suggest any real-life experience: movements and animation thus won't be compared to those we see every day. So the animation seemed to be more simply achieved if vector graphics is used.

Concerning the choice of software, we preferred Illustrator to Corel, as Illustrator makes part of a huge Adobe family, and its native .ai format can be imported directly into another Adobe program: Flash, in which we decided to create the prototype of our application. This compatibility was important for us, because even though it is possible to draw vector shapes directly in Flash itself, preparing elements in Illustrator and importing them allowed us to make them look more sophisticated, using latest Illustrator features (see the section "Creating graphics in Adobe Illustrator").

2.4 Character design

After discussing the motivation for fulfilling the educational activities with special educators, directress of the nursery school and our supervisor, we came to a conclusion that children are more willing to take up an activity while accompanied by a friend or being directly in the role of helping a friend (we will return to this concept of friendship among little children in the Interaction Design chapter). Considering all the design outputs we described earlier, we were led to the idea of employing a friendly character for each of the four activity fields we decided to cover in our application. Such characters will briefly introduce themselves, so that children can find out what sort of task is related to which character; these characters will then request help or invite children to join in. Introducing characters that invite children to take part in a certain activity seemed to be a more perspective concept than just request children to fulfill an activity without outlining any aim. Explaining the goal helps children to see more meaning and motivation in it. Sometimes children (and not only them) lack motivation because they can't see any purpose in what they are asked to do. We will thus try to explain all the tasks in a clear way, which aims to provoke children's interest and desire to continue learning.

We thus took the four categories of activities preschool children should practice, and decided to create a guide character for each of them. Besides the reason we mentioned above, we also wanted the children to feel at ease and not alone in the world of learning, and allow them to make friends inside the application so that they can find themselves supported. Another motivation was to make it easier to guess which category focuses on which field, and what sort of activities is ahead - it is not likely for the children to remember an inscription (which they mostly can't even read) or a complex image, but they might recognize an activity that is reflected in the design of its guide character's appearance, or at least gain a rough idea on the field the character is associated with.

In compliance with [37], putting a face on something makes it interesting and memorable in terms of graphical communication, as we are used to remember the faces and their configuration. Also, they claim that "character design is a contemporary graphical language", conveying a meaning beyond alphabetical syntax. Character design can also be compared to logo design, as it uses abstraction and metaphores [37].

According to [27], young children's faces always have a fragile, unsullied, open and honest look, which make them "attractive" to look at. Even the protagonists of series intended for children are mostly designed to fit these characteristics. The rules to create a childlike (and thus fragile and sincere) face require rounded shapes, big eyes, small nose, high forehead and small, short chin. Thanks to these features, characters gain a friendly expression which is necessary to make them popular. See Figure 32 on the opposite page for example.

While designing four characters for our application, we aimed to make them look cheerful and happy, as well as inviting-to-a-play looking. As we work with children and try to teach them something new, we should take the concept of "learning through playing" into consideration; it is always simpler for them to remember something that is accompanied with pleasant pictures and in a context of plausible, playful and warm environment. The

"learning through playing" concept was also greatly emphasized at the "Designing for children" conference that took place in India two years ago.

***Figure 32**: Ringo, one of the main characters of the Casshern Sins animated serie (Madhouse, 2008). Note the exaggerated size of the eyes, as well as the chin shape and small nose and mouth. Ringo is a young girl whose character was portrayed as a pure soul, and her appearance makes it well believable. See Appendix 1 for more visual references.*

Children must feel entertained and not bored or frustrated while using the application, and according to [27], interfaces that are nice and attractive are perceived better and even more usable by those who interact with them. This finding should be applied even more thoroughly in case of our target group: as we have already stated above, children are used to being surrounded by bright colors, smiling characters (puppets, cartoon heroes, plushies…) and things considered "nice" or even "cute" in general for most part of their preschool lives.

For each of the characters, we tried to find a visual metaphor that is the most evident for the corresponding field of educational activities. Creating visual metaphors is always tricky, as people's associations with objects differ a lot. On the other hand, children usually select their favourites on the first sight, without paying much attention to the details; so, instead of trying to achieve unshakably precise visual metaphors, we concentrated mainly on making each of the characters look distinct and original, making it easy for the children to distinguish them well one from another.

As we first though of employing just one character as a guide who would accompany the children through the whole application, we gave much thought as to how should it look, and especially whether it should be a girl, a boy or a fairy-tale-like being. We found out that preschool children always tend to make friends of the same gender (see the next chapter), so introducing just one single character can put one group at disadvantage. As we finally opted for making four different fields and let each of them be guided by a different character, it appeared only natural to employ two girl-characters and two boy-characters to be impartial.

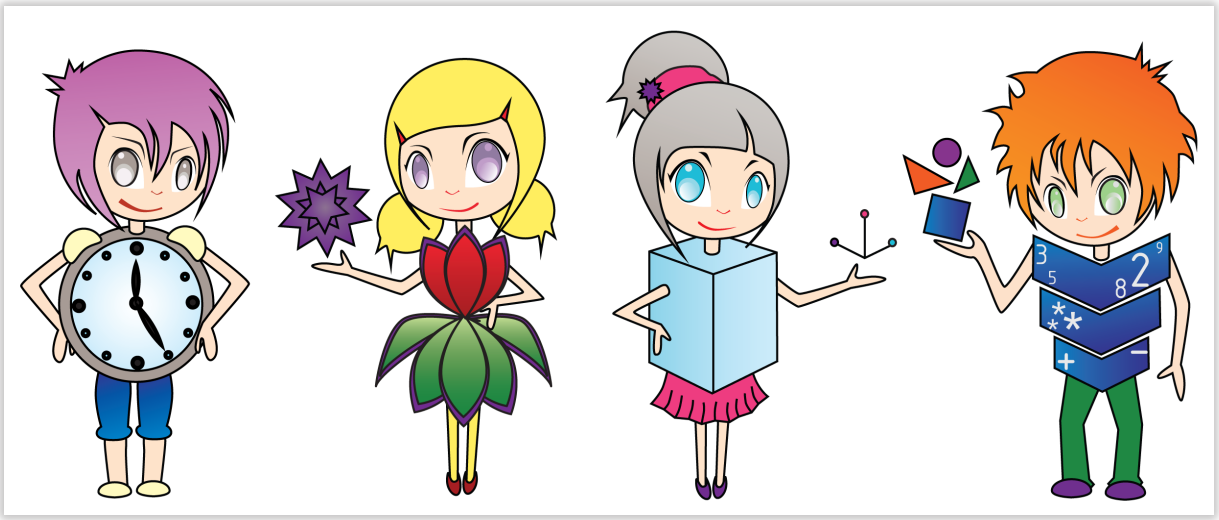
As mathematical concepts and time perception suggested a bit more "technical" prerequisites than visual perception and space perception, we decided to to assign boy-characters to the first two fields mentioned. We should emphasize though that this matching should be discussed further with the children, asking them how should characters who are expected to help them gain knowledge from the designated areas look like.

Taking all the hints described into account, we designed four characters who are embraced in the same style, yet hold their own original traits: they all have big heads, large eyes, small chins and mouths placed low in the faces, achieving the concept of the baby-looking face. We provided them with simple, conceptual limbs without many details such as fingers, because these would make the animation unnecessarily difficult. As a manga artist Hideaki Sorachi suggested, characters within the same serie should be designed in a way that would make it possible for people to distinguish them purely by their silhouettes. We tried to take that into account as well and created a set of four characters using different shapes.

Even though children tend to name their toys and plushies themselves, regardless the designated titles given to these by their manufacturers, it appeared inherent to name the characters considering the fields they guide children through. We also felt that naming the characters within the application could also contribute to their consistency, getting them closer to the real-world friends.

2.4.1 Space perception character: Krychlička

Concerning the character we created for the field of space perception and orientation, we employed purple color that is attractive for children (see the section "Colors for children" above) and accompanied it with blue and violet to achieve harmony. We also used light blue to white gradient, which develops the idea of space. Gradients in general fit well larger surfaces, as using one color only can look boring: gradients give these surfaces a more "spatial" look, even in case only slightly different colors are



BUDÍK (TIME PERCEPTION)

PAMĚTKA (VISUAL PERCEPTION AND MEMORY)

KRYCHLIČKA (SPACE PERCEPTION AND ORIENTATION)

POČTÍK (FUNDAMENTAL MATHEMATICAL CONCEPTS)

***Figure 33**: Characters we designed for the educational application. Note the color choice as well as the use of diverse shapes while conserving the same visual style. The characters above represent a re-draft of the very first concept we proposed to children; the character who had to undergo the most significant change was the one associated with mathematics, although we slightly altered all of them. See Part III for more details.*

employed - such as the two tones of grey in case of Krychlička's hair. See the picture above.

2.4.2 Time perception character: Budík

The obvious inspiration for the time perception guide character was an alarm clock: the clock face worked well as the character's body, while the bells at the top provided a nice allusion to short sleeves or even shoulders. Working with the clock face immediately reminded us of the steampunk style in which antique watch with classic face play a significant role - so we decided to dress the character into breeches, a garment that is another steampunk feature. It is not that we would presume the children to have knowledge of this style, but we wanted to make each character look different and employing different fashion seemed one of the options to make this possible. Regarding the color choice, dark blue of the breeches creates harmony with the violet hair, and both these colors are put into contrast with yellow of the shoulders and shoes.

2.4.3 Visual perception character: Pamětka

At first, we thought that we should equip the visual perception and memory character with a big pair of glasses, but then discarded the idea as it didn't seem to work well in terms of visual appearance. Visual metaphors that put glasses into use are mostly associated with the action of magnifying, which is not our case. As activities from this group embrace among others also these that teaches children to discern a figure from background and learn that a whole is made of parts, we decided to use a flower-based shape made of several smaller forms of the same nature. The dress worn by the character are also partially symmetrical - a property whose identification makes also part of the visual perception knowledge. The spiny object Pamětka is holding is a ten-tip star, created by superposition of two five-tip ones - which are shown in the center. Again, we do not expect all the children to recognize such connection, but the spiny object can at least attract their attention and provoke their interest. Concerning the colors, we combined the harmony of red and violet that contrast with the one created by green and yellow.

2.4.4 Mathematics character: Počtík

The character handling fundamental mathematical concepts should also teach children to recognize what is smaller and what is bigger, which led us to the idea of making his body out of three shapes that differ in size. He also holds three basic forms children are supposed to know before coming to school: triangle, circle and square. At the beginning, we did not include the numbers and other mathematical symbols in his outfit, but then we decided to do

so as children tend to think the character who is supposed to teach maths is the one handling space perception (see Part III for more details). Regarding the colors, we used the harmonious blue and green, which resulted in contrast with red-orange and violet.

The characters were created in Adobe Illustrator and as we intended to continue using them in Adobe Flash, we had to find out which rules we need to stick to. Besides the necessity of RGB color mode, we discovered that artworks imported in Flash should not contain groups, because it is impossible to animate them afterwards. Flash can respect layers as they were created in Illustrator, so it turned out better to use layers rather than groups.

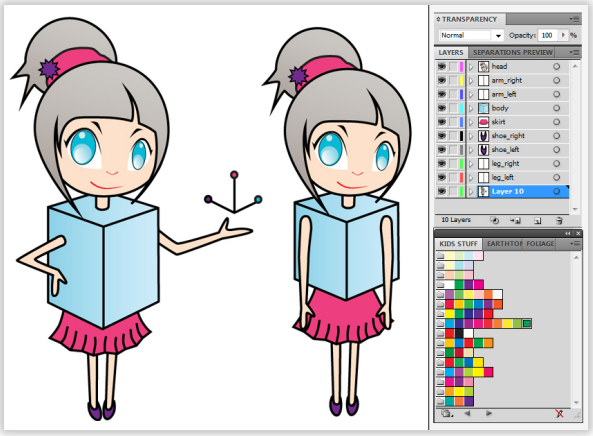


***Figure 34**: On the left, the artwork of the space perception character; in the middle, the same character ready for export into Flash. Note the distribution of the elements into layers and the swatches with colors suitable for children-centered design.*

We will describe the process of creating artworks in Adobe Illustrator more into details in the section that follows.

2.5 Creating graphics in Illustrator

Adobe Illustrator offers such a wide range of professional tools for creating vector graphics that some artists use it even for preparing presentation slides. We worked in the Creative Suite 5 edition, and even though our aim was to make a simple artwork and not a complex masterpiece, we still had the opportunity of employing the newest features such as width tool that allows to adjust variable thickness of the stroke, or even the perspective grid tool that makes it easier to draw in three-dimensional space correctly.

Most of the time, we already had a rough idea of the shape we wanted to produce, as we first made some sketches to clarify the character and setting design; then we drew the outline with the pen tool and then added anchor points to create rounded forms (see the picture above). When producing characters' heads, we appreciated the possibility of employing ellipses, which Illustrator offers together with other elementary shapes such as stars or rounded rectangles.

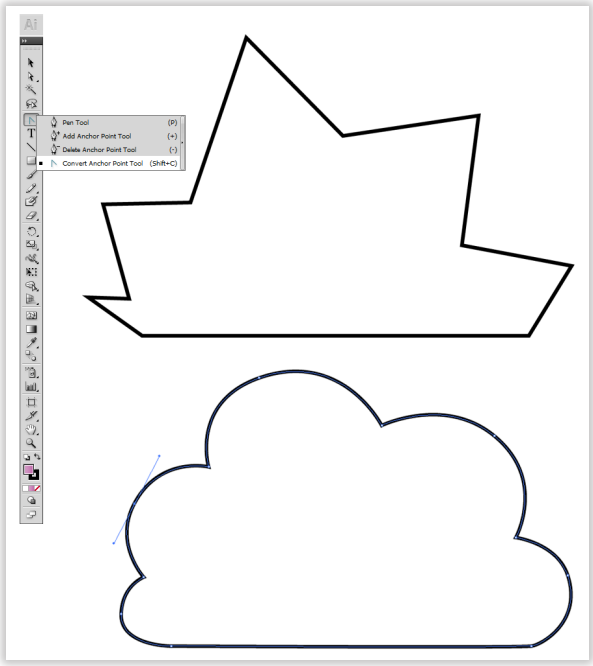


***Figure 35**: Above, a rough sketch of the cloud created with pen tool; at the bottom, finished outline.*

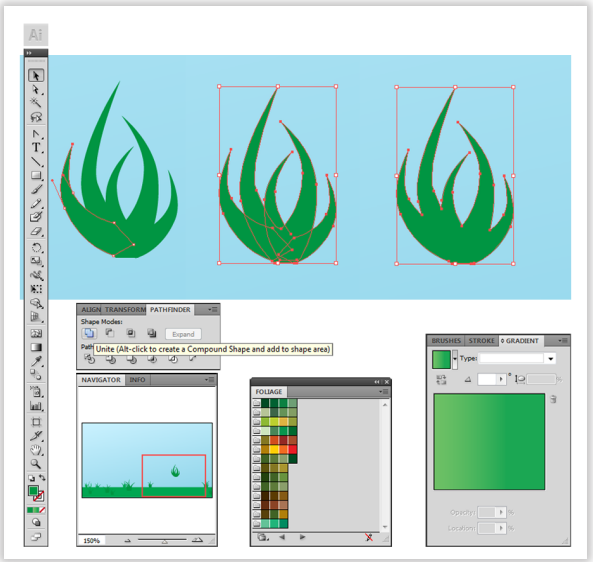
Following the visual references we mentioned earlier, we assigned both fill and stroke to the shapes we created: we employed two points thick outline the most often.

Working with vector graphics means working with a load of points, anchor points and control curves. Besides making use of the possibility to lock layers, it is also wise to unite (rather than group) the objects made of several distinctive parts, as it allows simpler manipulation with the objects as well as making it Flash-export-ready. In the case of grass that we used in two scenes in our application, we simply created a basic shape of one blade and then copied it until we obtained a whole tuft. It is extremely easy to mirror, rotate and scale objects in Illustrator, so we have always used this possibility while creating more complex elements (see the Figure 36 and 37 on the following page).

To keep the same style and maintain an effective workflow, we kept re-using elements, such as arms, boots, basic head shapes, eyes or even parts of the hairstyle (note the resemblance of the topknot the space perception character wears to the bunches the visual perception character has). Copying and mirroring objects proved to be a quick way to ob-

tain a lot of artworks in relatively little time.

Despite emphasizing the fact that we aimed for simple style of the graphics, we didn't forget the necessity of obtaining visually plausible compositions. Working with vectors in a two-dimensional canvas doesn't mean we cannot achieve three-dimensional effect or real-life-looking objects; shadows, gleams and reflections can be achieved using layers, multicolored gradients, opacity and even three-dimensional meshes that add depth to the surfaces we have applied these effects to (see Figure 38 and 39 on the right for examples).



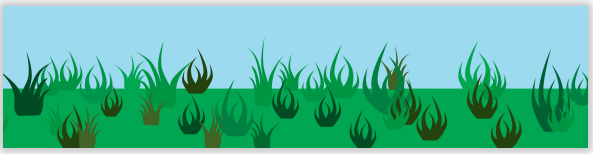


***Figure 36 (above) and 37 (below)**: A whole turf of grass created by scaling, mirroring and rotating a single blade. Finished object is united using the Pathfinder tool, which works in a fashion similar to the ProBoolean operations in 3ds Max. Below we can see a finished lawn with more or less similar turfs we created by copying and mirroring the existing ones. We relied on the Foliage swatches available in Illustrator while assigning the colors.*

Creating artworks in Adobe Illustrator can look very easy, but it is only an impression. The truth is that producing shapes that are defined exactly by curves equipped with anchor points is more difficult than creating rough bitmap graphics. The reason is that while defining shapes, we need to capture the form in an exact, "correct" way. If the anchor point is inserted on an inappropriate place or the control curve isn't adjusted well, the shape immediately looks poorly, even if only one section needs to be

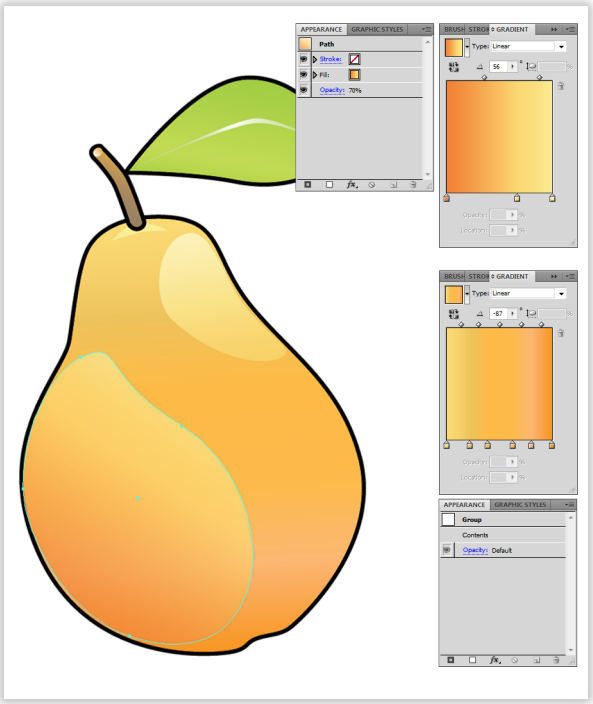


***Figure 38**: A pear: while the main shape is filled with six-colored gradient and default (100%) opacity, we filled the shiny areas with 3-colored gradient with 70% opacity to achieve a more realistic look.*

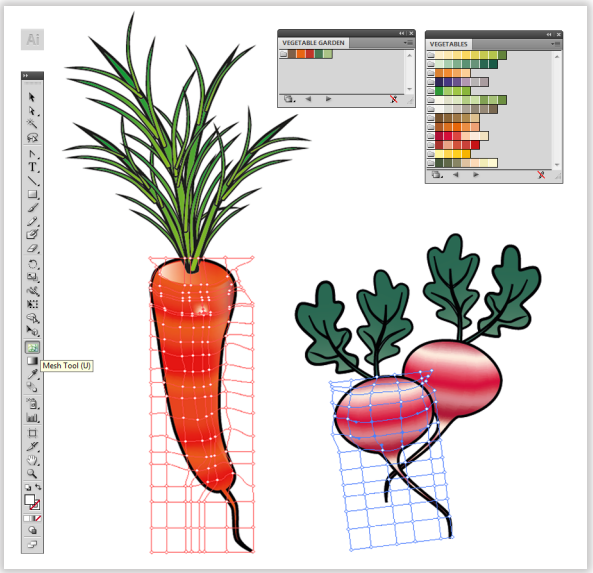


***Figure 39**: Carrot and radishes: the "spatial" look of the multicolored gradient was achieved thanks to employing the mesh tool. Points of the grid can be added, deleted and moved at free will.*

corrected. For instance, while working on the hairstyle of the time perception character, it was a bit tricky to find the right place where to put the tuft that is supposed to be exactly on the pate.

In a way, we can even compare creating simple vector shapes to low-poly three-dimensional modeling: as we have only restricted means to ex-

press the desired information with, we need to focus on the basis and omit the details while still maintaining the main features to obtain a simplified object that can still convey the information in an understandable way.

As we wanted to achieve a style of storybooks and colored workbooks children tend to like, we applied two points black stroke to almost all the objects: besides contributing to the creation of a particular style, bold outlining also helps children to distinguish characters from the background and identify objects easily at the first sight.

***Figure 40**: A render of a simple scene that can serve as a setting for the space perception and orientation activities (rendered with V-Ray 1.5 SP 5). Children can be asked to pick objects placed on the right side of stairs, on the table or on the floor. However, the absence of thick black outlines on the scene elements make distinguishing the objects a bit more difficult.*

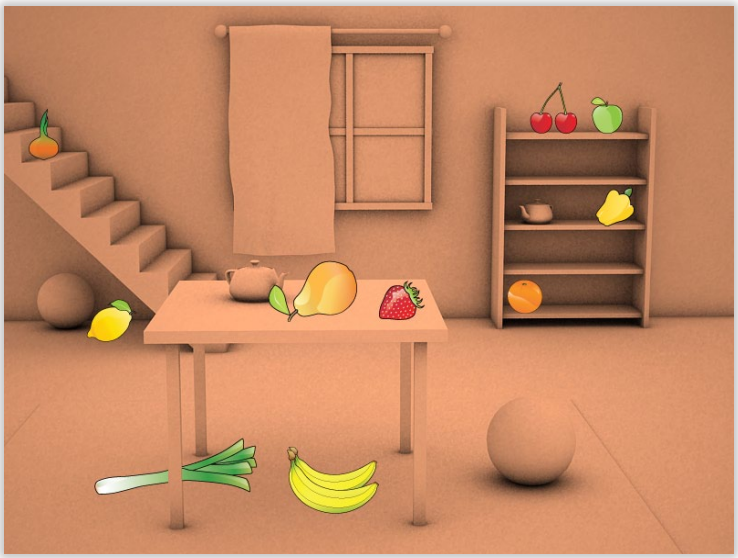


***Figure 41**: The same scene as above, only rendered with an overriding material. The absence of shadows the vector objects should have produced make the image look unnatural and poor in terms of visual experience.*

At first, we wanted to create in Illustrator only the guiding characters and some simple, basic objects they (and thus the children) would interact with; the background and the rest of the scene was supposed to be a bitmap drawing made in Photoshop. We thought that it would make it simpler for the children to differentiate between the objects they can interact with and the static pictures, as young children may have problems with omitting irrelevant information. According to [38], "younger children have less ability to inhibit irrelevant information and sustain attention in a central process. Only around the age of sixteen will children reach a level of resistance similar to that of adults". After consulting this concept with the directress of a nursery school, we decided to abandon this idea, as we learned that visual inconsistency may provoke more confusion than cognitive overload caused by too detailed pictures.

We also thought about employing renders of three-dimensional scenes as backgrounds to provide more lively experience of the space perception related activities (see pictures on the left side), but abandoned this idea for the same reason (see Part III for more feedback on the rendered scenes). At the end, all the interface including settings was created in Adobe Illustrator (see pictures on the following page).

2.6 Graphic design summary

In this chapter, we tried to describe the complexity of designing artworks intended for children and provide some guidelines resulting from research. We explained the importance of colors used in children-centered design, and emphasized the role of plausible, easy-to-read visual style: children are happy when they can understand what is going on on the image, and thus grasp well the situation; otherwise they may quickly lose interest and give up on trying to comprehend the situation. So there is a strong necessity to create a

visual style that is clear, children-friendly and children-appealing at the same time.

We can summarize the children-centered graphics design rules on the following list:

- use bright colors; these that are not commonly seen such as purple are more likely to provoke children's interest
- couple color harmony with contrast to achieve nice-looking combinations
- use clean, simple and outlined rounded shapes without unnecessary details
- try to create visual metaphors that would appeal to children in an understandable and interesting way
- while designing children-friendly characters, take the baby face effect into account: include big head, large eyes, small chin and little mouth
- if text is needed, prefer sans-serif font to the serif one, and try to use it as seldom as possible

We also tried to briefly describe the process of creating such graphics in a software tool that seemed to be the most appropriate: Adobe Illustrator. Below (Figure 42) you can see a finished scene for the fundamental mathematical concepts activity.

For more information concerning feedback on the artworks created and suggestions for improvements, see Part III of this work. To learn more about the interaction design and building the interface in Adobe Flash, continue to Chapter Three on the following page.

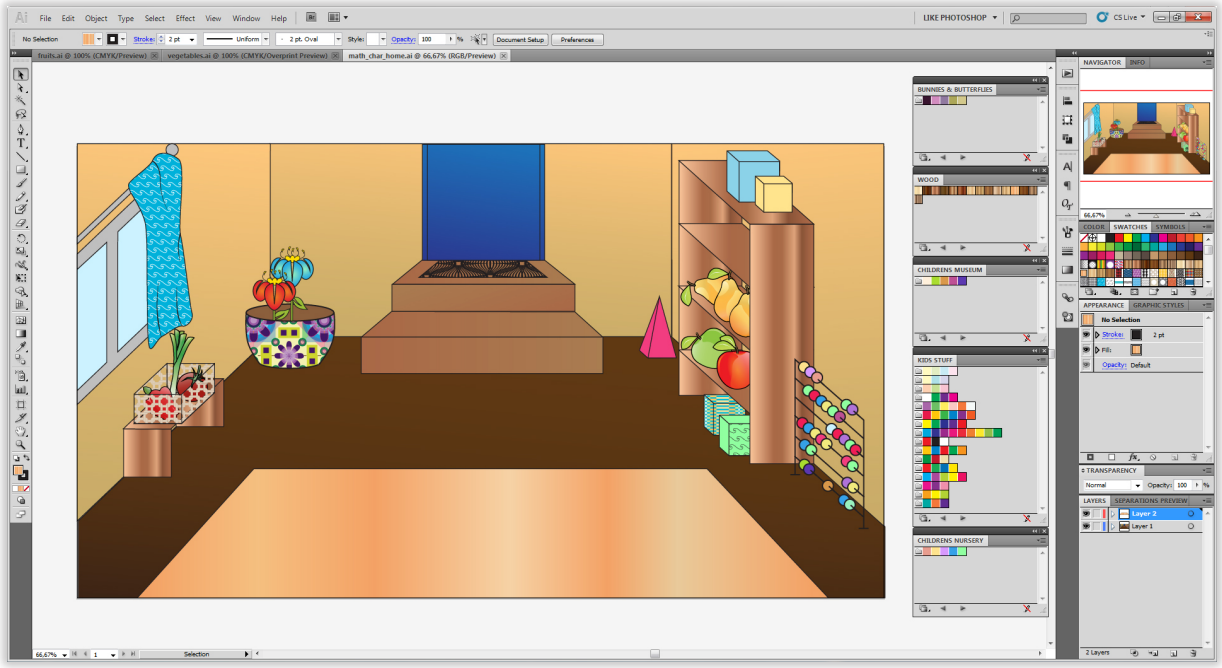


***Figure 42**: Finished scene designed to be a setting for the fundamental mathematical concepts activity. Note that the table is in a separate layer, as the character is supposed to enter the room via the blue door and then stop in front of the table. Flash can read Illustrator's layers, and it will be thus possible to put the character in front of the whole scene, yet behind the table. Compared to Figure 40, this scene appears much more simple, but considering the time spent with the design and creation, both scenes can be considered as equally time-consuming. The latter one is more suitable for children as there are no shadows and the scene appears visually consistent. Note also the use of swatches displayed on the right side.*

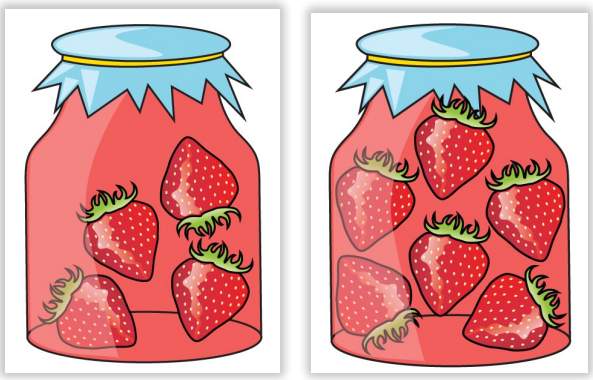


***Figure 43**: The bottles with strawberry compote (on the right) the character is supposed to interact with were created separately and imported to Flash as Movie Clips.*

Chapter Three: Interaction design

We now understand the fundamental principles of children-centered graphic design and possess knowledge necessary to create an interface for our educational application in terms of visual point of view. In this chapter, we will look into the interaction design and try to establish, in a way similar to the one of the previous chapter, a set of rules to follow while designing controls of an application intended for children.

3.1 Interaction design defined

According to the online presentations available at [39], interaction design means "designing interactive products to support the way people communicate and interact in their everyday and working lives". The goal is then to provide people with usable (easy to learn, effective to use and enjoyable to experience) products, involving users in the design process.

Concerning physical things including interfaces we use every day, there are affordances to help us figure out how to use them [41]; however, computer interfaces in general are virtual and don't possess affordances like everyday objects. Still, there are designs that help us understand what to do with the controls presented, like scrollbars that afford moving up and down or icons affording clicking on - such affordances are "perceived" [39]. Understanding what kind of action is needed to explain to the interface what we want to do is achieved via learned conventions or mappings between action and effect on the interface. Obviously, some mappings are better than others, and some can be so sophisticated that only people from a certain group can understand how to use them. In this chapter, we will focus on the interaction that is designed while taking children users into consideration.

3.2 Learning through observation

Getting children to cooperate on our project proved to be difficult, as parents tend to be enormously suspicious and often refuse their children's participation, whether it consists of stating their preferences concerning graphic design, providing an early feedback on the first sketches, or testing the prototype of the interface. That is why we had to assemble the clues necessary for a good interaction design from papers published on the problems so far and via observation - which seems to be the most acceptable way for parents. It is extremely important to keep the eyes open whenever an opportunity to meet and interact with the target group shows up, because every detail in the behavior can help discovering important aspects of the preferences and habits.

In order to learn more about the behavior, customs and working habits of preschool children, we asked permission of the directress of ZŠ Žernosecká (where we have already observed the enrolment - see Chapter One) to be able to assist at one of the preparatory courses they offer. Such courses are intended for children aged six or seven, who were accepted to the first grade and are expected to start their school attendance in September. Children attend these classes once a week during the summer semester, and each course takes 45 minutes - the length of a standard primary school lesson. We were invited to one of the latter courses, as the directress wanted to make sure children are used to the routine by the time.

At the beginning, the directress told us that these courses were established purely to prepare children to the school life and ensure that they are not afraid of coming to classes and can feel more relaxed about starting a new life. According to [42], the aim of these courses is thus not to improve the school readiness nor maturity (as these need to be developed already while enrolling at school) but to show the main differences between nursery and primary school to the children. They need to learn to sit patiently at the school desk, raise their arms when they want to talk, and then express their opinions only after being called by the teacher [42]. This last rule was considered the most important one, and, as we witnessed ourselves, the most difficult one for the children to follow.

The afternoon we came to attend the preparatory course was raining, and the school cloakroom where we were supposed to wait for the teacher was filled with multicolored umbrellas. We also noticed that the lockers pupils used were painted bright green and yellow alternately, and together

with brilliant tones of children's clothes confirmed the fact that young children prefer bright colors. After reporting to the directress, we had an opportunity to speak with the school guidance counselor. She was very curious about our project and explained that she is defender of usage of modern technologies, such as the interactive blackboard, at school. She added though that the technology itself is not enough, and that she feels that much more thought could be given to the exercises design. "Some programs are good, but some are just totally inapplicable," she claimed. According to her opinion, some programs that were designed for the interactive blackboard were unnecessarily complicated and only made children confused.

The children attending the preparatory courses were brought to school by their kindergarten teacher, who also helped them with placing their boots and jackets on the designated place. She kept the children company until the primary school teachers arrived; the 28 children who have just arrived were then divided into two equal groups. The first one was called "giraffes", while the second one "kangaroos". It seemed that all the children knew well which group they belong to and took their places in line proudly. However, as they needed to wait a bit for the teacher, they started to be restless, unable to stay on one place, and their lines were soon scattered. We comprehended then (and confirmed even several times later) that preschool children have still little patience and tend to turn and look in all directions when excited. We were thus very curious how are they going to behave during the lesson, when they were supposed to sit patiently at their school desks.

The giraffes group we followed was made up from six girls and eight boys, who took places in a standard primary school class (see Figures 44 and 45 on the opposite page). An interesting phenomena we observed was that boys shared desks with boys and girls with girls; it proved that preschool children tend to find friends of the same gender, even in a group as close as a nursery school class.

We were also interested in the relationship that has developed between the teacher and the children: she told us that most of the time they get used to their instructor very much, and then require him or her even after starting the first grade. So we were curious whether she presents herself more like an authority or more like a friend. We found out that it was something in between: she acted like a friend when explaining that children should not scream ("We won't be able to hear one another") and sharing a "secret code" (1-2-3) that was supposed to be an impulse for everyone to become quiet; yet when the same pupil kept shouting out without being called, she acted like an authority and explained to him that his behavior was inacceptable and that he was disturbing the whole class.

As the class we attended was right after short holidays, children were first encouraged to share their experiences with others. The teacher let about four children talk for a while, and then discussed the weather with the rest of the class: "Is it appropriate for this season? Why?", so that everyone got to speak. We noticed that most children were able to speak without any problems in a very fluent way. They talked about how they spent holidays at their grandmothers' and sounded almost like middle school pupils. Some children were angry at the rainy weather, but one girl explained that "Without rain, flowers won't be able to bloom", and sounded almost like an adult talking to her own children. We wondered whether this was the explanation her mother told her. Then they sang a familiar song reffering to weather together, and the teacher accompanied them on guitar.

After this introduction, the children were asked to present their homework. We noticed that all of them already had fully-equipped and brand new pencil cases, which they seemed eager to use and show to their friends, explaining which serie the character printed on the top came from. As the session advanced, we started to understand that it is really difficult for children to keep totally quiet and sit properly - so far they were used to start talking when they wanted to, and now they had to wait with sharing their ideas and experiences.

The homework seemed to be perceived as easy: it consisted of coloring a few images. The children were obviously promised an animal-like rubber stamp mark for finishing it, and the teacher asked them which ones they already had in their little collection. Then she announced which will it be this time: "It is green and can jump really well." All the children started to raise their hands and the one called said: "Frog!". "Correct," the teacher answered and started going round the class, distributing the stamp marks. However, when somebody didn't have it finshed, the teacher made no exceptions and refused to give the frog mark. We didn't hear any excuses such as "I forgot it at home, but get it done" - all those who did not complete the coloring honestly admitted they didn't do it. That was an interesting finding: preschool children weren't lying nor trying to present themselves better than they felt they were: what we experienced was a complete honesty.

***Figures 44 and 45**: Pictures of the classroom the course took place in. We took the photos after all the children left to prevent any problems. It appeared the classroom was used by the first grade, as pupils left their spelling books and some notebooks on the shelves below the desks. We were also positively surprised at seeing that not only this classroom, but the whole school was decorated with artworks made by children, creating a very warm atmosphere. Embellishments produced from colored papers were omnipresent, and the teacher explained that the school offered a lot of creative after-school activities. With all these decorations around, children can feel less stressed by the unknown environment: the school resembled a lot to the kindergarten.*

Another important discovery we made was the fact that children tend to help each other a lot. When a boy from the second row dropped a pencil, the one sitting in the front row bent and picked it up for his friend, placing it on the top of his table. And when one of the girls found out she didn't have a pink-colored marker, another one (this time from the opposite side of the class) offered to use her own. This finding was of extreme importance, because we discovered children tend to help others if the situation requires so. It thus confirmed what our supervisor told us: children are helpful.

After checking the homework, the teacher gave everyone an A4 paper folded in a way it looked like a sail of a boat. The children were supposed to use scissors ("Carefully! Do not wave them!") and cut out the protruding part. As soon as the papers and instructions were distributed, the children were quiet for a short while, all occupied by cutting the paper as smoothly as they could. The teacher emphasized that they should proceed slowly, yet very carefully, and the children seemed to do so. After everyone had finished, the teacher asked what shape did they get. Some thought it was a roof, another ones claimed it was a tent. Finally, one girl observed it was a triangle. So we saw that the teacher was not as much "teaching" as asking the right questions and letting the children to come to the conclusion themselves. Then the children named also the rectangle and the square, which they obtained by unfolding the paper.

We also discovered that children really had an incredible imagination and weren't afraid to express their ideas: after folding the triangle on both sides, they obtained a shape more or less suggesting a dog's head. When the teacher asked what shape does it remind the children of, one boy immediately called: "A fighter plane!". What was interesting was the fact that nobody laughed at him, and the teacher just asked whether anyone had a different opinion. They got to the right conclusion eventually, and the teacher then suggested to draw eyes and muzzle on the paper. Children compared their dogs one with another, observing mainly the ears' size. The teacher

emphasized that all the dogs were nice and just as diverse as the real ones, and then helped children to clean up their tables.

When a first grade pupil entered the classroom suddenly and explained she came to retrieve a forgotten book, many children turned and observed her with admiring gaze. We felt that they take the school attendance as a sort of status.

Then we noticed the children started to be restless, and so the teacher decided to incorporate a simple physical activity: they formed a circle around the middle row, held hands and started moving clockwise while reciting a rhyme. We witnessed that this activity was very welcomed by the children: they were really happy to be able to move around. Some were running faster than others and the teacher had to explain they can't do so because they can hurt themselves or the others. In general, we observed that children were very open to all the explanations and discussions and accepted the rules as the teacher explained them in a clear manner.

After this short motion activity the children returned to their desks and tidied them up, putting the cuttings into dustbins. We thought that the timing was well prepared: first, the children can move around and enjoy themselves, which will make them feel good, and they will then be more willing to proceed with the cleaning.

As the end of the lesson approached, children were asked to pack their stuff up, but then still remained on their seats and the discussion continued. Talking in class was emphasized and encouraged, because children needed to focus on the person who was talking and be able to grasp what he or she talked about; pupils also needed to raise their hands and talk only after being called, which was an important rule they needed to master.

The teacher asked them about their favorite toys, and children started describing all kinds of playthings they had home: car and plane models, plushies, living animals... and surprisingly, nobody mentioned computer nor any electronic device. That was also an important finding for us: as we talked with special educators before, we started to believe that children were all passing their whole days in front of a computer screen, which obviously wasn't true. We also noticed that the teacher encouraged pupils to develop their descriptions, and explain in a clear way why do they like certain toy more than another: for instance, a boy in the first row claimed to have "three cool legos" at home, and the teacher asked him to clarify the word "cool" - why did he think the legos were cool? So the boy said he just liked them very much.

At the end of the lesson, the teacher addressed the children and praised them for being cooperative and well-behaved during the lesson. The children were obviously delighted and some of them promised to bring their favorite toys next time and show them to the whole class. We understood that being encouraged and praised is extremely important for preschool children, especially when taking on a new, so far unknown activities and tasks. As they were cleaning the classroom before leaving, some children produced drawings they made during holidays and showed them to the teacher. She liked all of them and commended all the children for being very skillful.

After the course ended, children assembled again in the cloakroom where the nursery school teacher was already waiting for them and walked them back to the kindergarten. Before leaving, the children said "goodbye" properly to the teacher, which we perceived as an act of respect and favor. We spent some more time with the teacher and requested feedback on some artworks - see Part III of this thesis.

Being able to see such course with our own eyes was very important for us. We were able to witness the target group at real work for the first time, observe their customs and preferences and see their natural behavior (the children didn't care about our presence at all - only one girl asked us whether we were going to be their teacher next week).

Besides this priceless information about their working habits, we also gained important insights into children's social life (gender preferences when it comes to making friends) or even their natures (helpful, co-operative inside the team). We were also able to see that our target group was made out of many diverse personalities, and our workflow was certainly influenced by our attendance at this course: we then knew exactly who we are creating this project for, and the general word "children" suddenly obtained a multitude of real faces.

3.3 Children-centered interaction design

After attending a preparatory course centered on preschool children, we also consulted worldwide materials that focused on working with children while designing new interfaces and technologies such as [25], [26], [33], [37], [38] and [40]. We found out that a lot of new technologies that are intended for young children are only seldom designed with their cooperation, and the design pro-

cess might thus not be taking all of their needs into consideration. One of the first specialists who started including children as testers, users and informants was Allison Druin, who claimed that "We need to understand how we can create new technologies that offer children control of a world where they are so often not in control." [40]. It means that the interaction in our application needs to be designed in a way which makes it *simple* and *natural* for children to control. Our aim is a child who can complete the tasks given and get the feeling of success from doing so - not a child who gets frustrated from not being able to "tell the application what needs to be done". It is important to provide the children with enough hints telling them how to control the application, while letting them finding the solution of the task given on their own.

Another problem consists in the fact that children have an immense imagination and tend to look on the world from a perspective that differs strongly from ours. The visual metaphors we have already mentioned in the previous chapter can work perfectly for teenagers, but might be totally inappropriate for preschool children - and the same risk applies to navigation and control of the application in general: reports from the interaction design sessions with children [40] claim that "children think, interpret and react to situations differently than adults; designing for them is difficult and understanding how are they playing and learning new things is necessary to design a good product". For instance, even small changes in the appearance of the interface can influence greatly the way children try to interact with it [33]: when there were squares on the carpet indicating positions of touch sensors, children "jumped vigorously" on them, but decided to step on them carefully while there were arrows used for the sensors' representation. This may be caused by the fact that a rectangle seems more heavy-duty than the arrow, and its shape is also simpler to recognize and understand than the arrow - which can look too complex, fragile, or even mysterious and thus somehow "dangerous".

Studies described in [33] and [40] confirm that children like tangible interfaces, as they enjoy touching and manipulating the devices - no matter whether they use a hand-held control, interact with different types of sensors or simply use their own bodies as a controller to affect the application's state. Allowing direct manipulation represents the best case, however direct mapping works as well [33].

In order to design a suitable control for the application, we tried to take into account not only all the experience designers shared via their papers, but also the knowledge gained while attending the preparatory course and information that special educators shared with us in the beginning: they all agreed that television-based application risks to turn into a one-sided activity. On the other hand, a television-based application was one of the conditions we needed to respect. According to [43], "there is rarely a correct answer to a design problem - designing aims to achieve a solution that is satisfactory or appropriate for the given situation". So we decided to find a way how to use television and still control the application in a children-friendly way. One of the solutions we wanted to avoid was using control devices children have problems working with, such as mouse and keyboard; according to [33], children often expect the applications to work on the same principles as the real world, requiring immediate feedback and direct manipulation interfaces. If a mouse is necessary, then all the buttons should have the same functionality, and double-clicking should not be required to control the interface [33]. Also, making children hold down mouse buttons can prove extremely tiring.

At the beginning, we thought that touchscreen devices such as tablets or PDAs might suit the application targeted at preschool children the best, as they offer the easiest controlling possible - direct manipulation. In addition, such devices are mobile and can be thus carried and used everywhere. On the other hand, such devices always require the child to just sit down and focus on the screen, which represents exactly the problem of one-sided computer-based activities specialists were so skeptical about. Moreover, young children can have difficulty trying to target small objects on the screen [33], which can prove to be a serious issue especially considering the not-so-well-developed level of fine motor skills preschool children have.

According to the assignment, we are designing for television: it might not have the advantage of providing direct manipulation, but it is a device which has achieved high-definition in resolution, and can offer big-screen experience - which simplifies orientation in the scenes presented. Finally, when combined with modern gadgets, television is an appliance that no longer provides passive entertainment only. As television cannot be influenced directly like a touchscreen, we needed to define a mapping that would be as close to the real-world experience as possible. We also aimed to avoid the risk of creating only one-sided activity as much as possible, so we decided to use Kinect - a device de-

signed for Xbox 360 by Microsoft - to control our application.

There are multiple reasons to prefer Kinect to other controllers. The most important one is that no pointing device is needed at all: children can use their own bodies and their movements to affect the state of the interface, and thus don't need to point a controller on the screen. Another reason to prefer Kinect is that children will not only sit infront of the screen and watch - they will actually have to stand up and move in front of the screen to be able to control the application. As we have described and explained in the previous section, children tend to be restless while having to remain on one place for a longer period of time, and lack physical activity (the teacher integrated simple exercise even in the 45-minutes-long preparatory course). Using Kinect will thus help the children to relax and have a stretch naturally even though they will remain in front of the television screen. Moreover, using their own body movements as controllers affects positively the development of children's motor skills, and avoids the criticized trend of children passing their free time laying in front of a screen.

As all design solutions, even this one has its drawbacks - for instance, children can possibly grow weary from an intensive interaction with the application. This will dramatically affect their motivation and concentration, without which they cannot acquire new knowledge and skills. The interaction should thus remain on a level which makes it possible for children to actively participate in affecting events on screen while avoiding excessive demands on moving around.

3.4 About Kinect

Kinect for Xbox 360 was released in 2010 in the United States, combining RGB camera, depth sensor and multiarray microphone (see picture opposite) that make it possible to track full-body movement as well as to recognize individual voices of the users [44].

According to a shop assistant in the console games store, Kinect is used in games that users can control by jumping, moving from one side to the other or waving hands; in the future, Kinect is preparing a feature that will make possible to affect the interface even

***Figure 46**: Kinect for Xbox 360 designed by Microsoft. This device should be placed below the television screen in front of the users to be able to recognize their movements and voices.*

***Figure 47**: Children playing Kinect games. Note the pure engagement in the activity.*

by bending fingers. With its "get off the couch" concept, Kinect brought a new dimension to the world of gaming, fitness and even learning trough playing, on which we will focus in this short section.

According to the video available at [45], "the children can feel at the heart of the learning experience, and not just passively absorb it" while playing Kinect educational games. Terry Fitzpatrick, the Chief content and distribution officer of Sesame Street claims that the user interface for preschoolers was the biggest challenge while trying to find a way to deliver Sesame Street to gaming platforms. He also confirms that the absence of controller makes Kinect a revolutionary tool for the young children, removing all the pointing-device-related problems [45].

Aimee Freeding, the User experience PM at Microsoft Studios explains that children primarily learn to play, so the designers took activities like running, jumping and hopping and turned them into an emerging learning experience. The video confirms that children are focused and fully engaged while completing the tasks presented in form of a game; they are also happy to be able to meet their favorite Sesame Street cartoon characters or see real animals in their natural environment.

Observing children playing Kinect games and learning about all the educational horizons convinced us that Kinect is the right device for an interactive educational application for preschool children: they can move

around and develop their motor skills while gaining new skills through a playful experience (see Figure 47 opposite).

Thanks to the fact that Microsoft released the Kinect development kit for Windows, it is possible to create and use Kinect-based applications on computers or even other Windows-embedded devices. The features embrace four Kinect sensors that can be connected to the same computer, and a camera that is able to recognize objects as close as 40 centimeters in front of the sensor [46]. Speech recognition is getting improved as well, and Microsoft is also working on better recognition of the person controlling the application in the two-player mode.

There is also a possibility of benefiting from the cooperation with Kinect-related open source projects, such as KinectEDucation community [47], where it is possible to share source code of educational applications written for Kinect, and learn about the projects that have been designed for this device focusing on interactive education.

After exploring the world of Kinect, we felt that it is a suitable choice in all aspects: both children and parents seem to accept this device glowingly (according to [48], "Microsoft sold an average of 133,333 units per day between November 4 and January 3, 2011"), and there is a large community of developers behind the technology, both shielded by Microsoft and independent.

3.5 Prototype design

After we picked the four activities' fields we wanted to focus on in our application, learnt about the most suitable forms of children-interface interaction and decided on the way the application should be controlled, we started with the prototype creation.

First, we needed to decide on the story behind each of the activities, so that they would seem more like a play than an exercise. We then proceeded with making sketches of the setting (or background) that needed to be outlined in Illustrator, and phrased the assignment. Choosing the right words was a bit tricky as it is difficult to guess which words children understand the meaning of and which sound unfamiliar to them. However, as we visited the preparatory course, we found out that most children have their vocabularies pretty developed and used words with complex meanings as adults.

Then we decided on the required interaction: what is the child supposed to do in the given situation, what will happen if the answer is correct and what will happen in case the answer is wrong. Both choices require an immediate and clear feedback, which should not be too strict or scary in case of the wrong answer, and praising in the case of the correct one.

The supportive reward structures are very important in an application intended for children [33], as it provides them with the motivation to proceed further in the educational process. Our aim was to base the reward system on the animations: at the beginning, a short animation introduces the story, which contains task(s) children are supposed to fulfil. If a task is completed well, then another short animation takes place, showing the approval of the guide character assigned to the activity field. At the end, a longer animation is supposed to conclude the short story.

We applied this procedure exactly in case of the fundamental mathematical concepts, creating the following plot: Počtík is going to visit his friends and wants to bring them a small gift. He needs to choose a compote which contains the most strawberries, and the child is supposed to make that choice. After choosing the right compote, Počtík nods his head and then leaves his house for his friends' one, carrying the strawberry compote with him (see the contents of the enclosed CD, the "prototype" folder).

As we still kept in mind that special educators were skeptical about long animations, we tried to make them as short as possible; in case of the remaining three activities, we even omitted the plot and created clipped animations, only briefly introducing the task. We wanted to find out which way the children would prefer.

As we were creating only a prototype of the application, we were not aiming to use Kinect to control the interface right away. We intended to make the prototype in Adobe Flash CS5 and test it according to the Wizard of Oz method [49]: "a user interacts with a non working interface prototype being controlled by a 'wizard' sitting in a back room: the wizard observes and reacts on the user's actions and simulates the system's responses to the user's actions". This way, we were able to create high-fidelity prototype in a relatively easy way.

The prototype is thus a Shockwave Flash interactive movie that can be controlled by mouse - scenes and animations change when certain elements on screen are clicked. As the instructions given are intended for an application controlled by Kinect, they *do not match* the mouse clicks needed for the appropriate advance in the activity.

For instance, when there is an announce-

ment from the part of a guide-character, the animation should proceed further as soon as the announcement is expressed. In an ideal case, each guide character should have his or her proper voice reading the assignments; as we didn't manage to achieve this by the time of the first test session, we had to *read* the assignments aloud in real time. Because of that, we had to place an extra step in the interaction: the movie stopped at the frame where the announcement appeared, and a mouse click was required to continue with the story. This way, we could make sure the assignments are read and understood properly.

Such extra clicks are not intuitive - the elements that need to be clicked are not clearly indicated (since these actions will not be required in the final application) and the prototype thus requires to be operated by someone who knows where to click to proceed further. We admit that it is not the best solution (the application needs a "guide"), but since we were creating a Wizard of Oz based prototype, where the actions of the user are simulated by a 'wizard', it should be enough to allow us to test the interface properly. To be able to find out whether the intended gestures would really work, we created a list containing the Kinect-based gestures that correspond to the mouse clicks (see Appendix 2) and indicated there which clicks are required only by the prototype. Following this list and observing the children's actions, we were able to find out whether the children would really employ the gestures necessary for the given situation.

The gestures needed to control the interface are designed to be very simple: concerning the prototype, most of the time only pointing at the screen is necessary. However, more gestures and even full body movements can be employed in the final program. For instance, we thought of an exercise consisting in recognizing the longest earthworm. To pick the animal from the ground (and thus fulfil the task), children will have to squat as in real life. Another task may consist in putting an amount of building blocks on the designated place, and children will need to grasp the bricks with both hands and move them. This way, the application will stay close to the real world experience.

Unfortunately, such control have its limits and can cause the following problem: children can have difficulties grasping the abstract concept of manipulating the objects on screen in real life. Presenting the interface in cave or similar 3D simulating environment could solve this problem, but it would not comply with our assignment.

The interaction required in the prototype we created for testing is as simple as pointing on the screen, which corresponds to selecting an object, and waving, that makes a signal for the application to quit the task in progress (children wave goodbye to the guide character).

The selection process is divided in two phases: in the first one, the object is preliminarily chosen, but there is still a need for the decisive confirmation. During this first phase, some additional information about the object in question may appear, sometimes offering a slight hint to the children. In the second phase, the object is selected firmly and the choice is evaluated. The first phase is necessary, as there is a need to avoid involuntary selections and dialogues asking for confirmation in an explicite way.

The first phase of the selection process was designed to take about three seconds (in case no additional information is displayed) or simply the amount of time necessary to present (read aloud) the detailed description or hint. These time limits were chosen according to the Kinect standards the game shop assisstant described: "Pointing at some menu item for about three seconds will select it or enter the corresponding submenu."

We deliberately didn't incorporate any similar time limits in the prototype, because we wanted to *learn* how much time does it take the children to make the decision from observing their spontaneous behavior.

3.6 Creating the prototype in Flash

As we have already mentioned in the previous chapter, we chose Adobe Flash because of its close cooperation with another Adobe tool - Illustrator. Offering wide possibilities of different animation styles, Flash is used for short cartoon movies, advertising banners on the web pages or interactive online games. The possibility of using a scripting language named ActionScript allows the creation of interactive components that don't necessarily have to be limited to buttons only.

Flash offers a designer-friendly environment, whose control is similar to the other programs from the Adobe family. Concerning the most important components of Flash's interface, there is the stage on which all the story takes place, a multi-layer-supporting timeline that enables the animation production and the library storing all the objects used on the stage. Beside these, Flash offers vector-based tools similar to these of Illustrator, such as pen, free transform or drawing basic shapes.

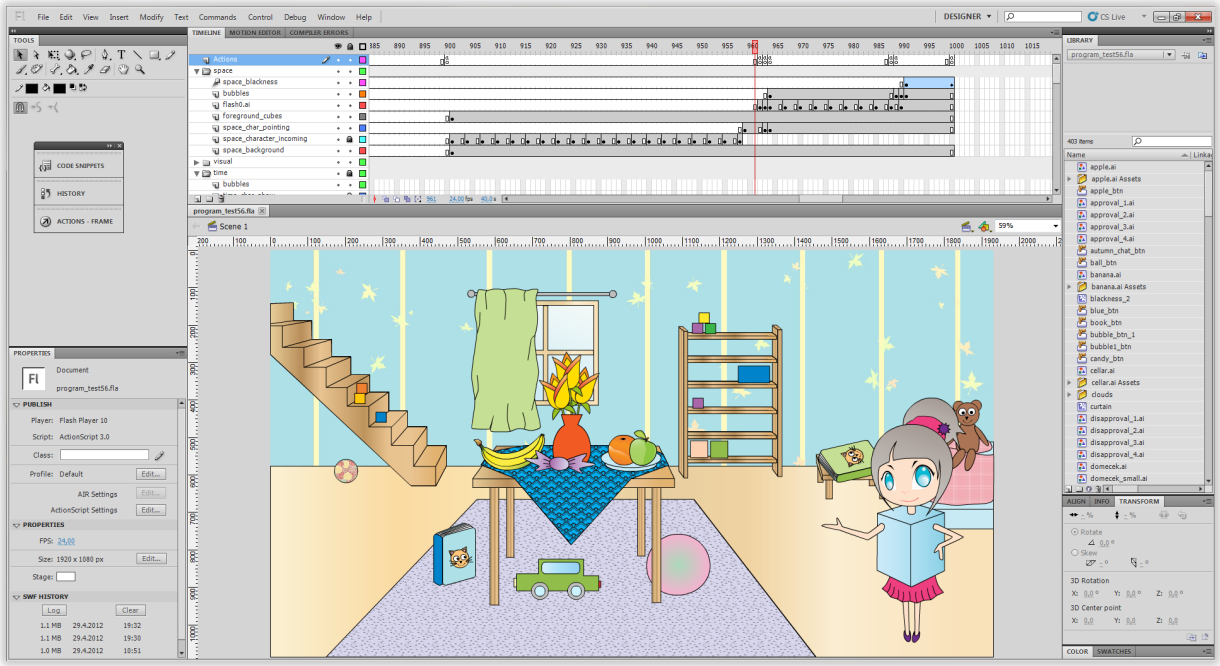


***Figure 48**: The black dots indicate that the corresponding frame is a keyframe - meaning that certain object(s) change their position or shape in that point on the timeline.*

3.6.1 Components handling

As we have already mentioned, there is a possibility of importing Illustrator artworks (.ai files) directly into Flash. There are three possibilities to do that: first, a standard Copy - Paste procedure; second, the file can be imported to the stage via the import dialogue, or third, we can import the artwork in the library and place it on stage when needed. Most of the time, we applied the last option, as having all the objects nicely organized in the library provides a useful overview of all the imported files. Thanks to the possibility of organizing objects into folders, it is easy to find out quickly whether an object has already been imported, and re-use it if necessary.

When placed on stage, the object can be assigned an instance name, which is important especially in case we need to assign some interaction to it. The instances on stage are also called Symbols and can take form of Graphic, Movie Clip or Button. The Graphic works well for all the static images that serve as background or decorative objects on scene, whereas Movie Clips suit all the animated objects. Converting an object into a Button Symbol allows an extremely easy interaction assignment, be it a mouse over effect, on-click animation or sound play [50]. Flash suggests to which kind of Symbol should the object be converted before animating.

3.6.2 Animation

Concerning the tools for animation, we can employ keyframes, motion tweens or an even more complex method using bones assigned to animated structures. We found all these methods useful and employed them for different sorts of animations in our prototype, choosing each time the most suitable one.

The keyframe animation is the most basic: objects can change their shapes or positions every time a key frame is inserted on the timeline. We employed this sort of animation for most situations that required an appearance of a character on screen: the very small figure emerged in the background, and became closer and bigger with every keyframe. An example of the key frame animation is well visible on the timeline on the Figure 48 above; follow Krychlička to see the resulting movement in the application (see the contents of the enclosed CD).

Motion tweens are used for smooth animation: we need to insert a keyframe for both initial and final positions, create a motion tween and Flash will compute all the frames in between. This sort of animation suits well blooming flowers or leaves flying in the air - in this case, it is even possible to set the curve on which the animated object is going to fly, adjust the object's speed, and determine how many times and in which angle the object will rotate during the animation process; see Figure 49 on the following page.

Motion tween can also be used in case we need to switch from one scene to another using the darkening technique, because motion tweens can be applied also on the aplha channel, affecting object's

transparency.

We preferred the use of the basic keyframe animation to motion tweens in case of incoming characters, as motion tweens are too "linear" and don't fit well the simulation of the human walking movement.

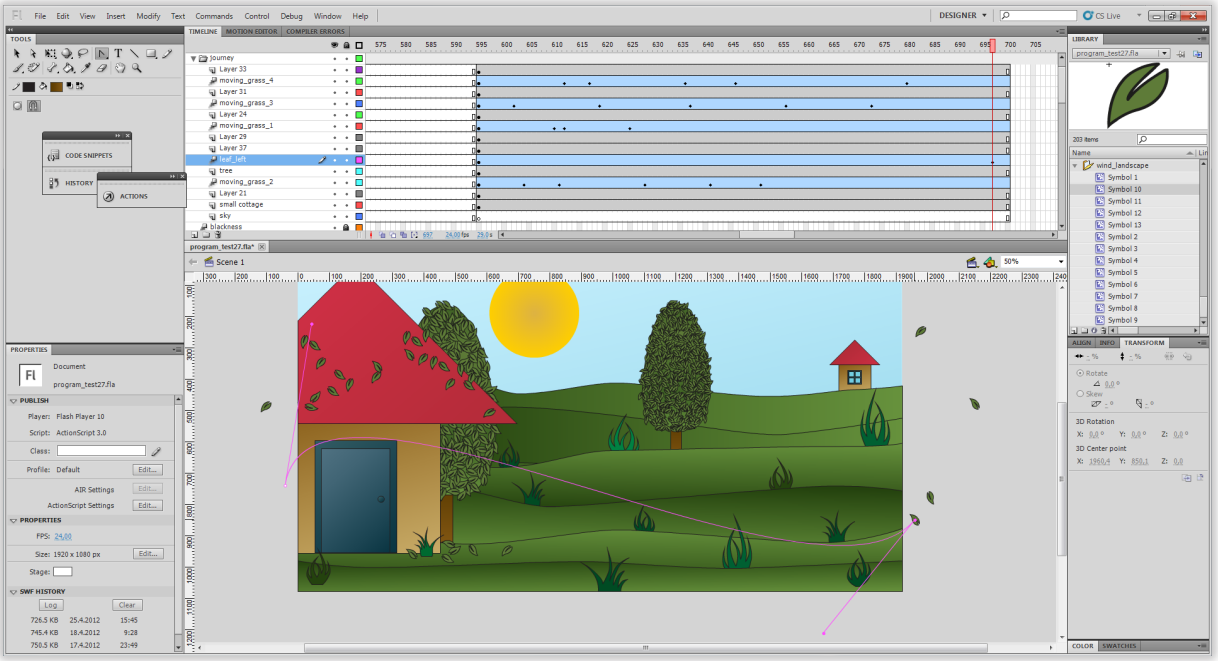


***Figure 49**: The pink Bézier curve defines the trajectory of the little leaf's movement - its motion is editable as well. Separating the animated objects into different, locked layers makes the manipulation with symbols transparent and avoids the risk of altering any object by mistake.*

Concerning the animation based on bones assignment, it reminded us a bit of the Biped based animation tool available in 3ds Max; even in Flash, it is now possible to create whole skeletons with bones and joints, which respect the inverse kinematics principles. As the inverse kinematics takes care of calculating all the necessary angles and positions during the animation, all we need to focus on are the original and final postures. See Figures 50, 51 and 52 on the opposite page for an example of a bone assignment.

Even though the idea of using bones and inverse kinematics in Flash is very interesting and simplifies the work a lot, it suffers from the same disadvantages as the Biped based animation in 3ds Max, where moving the bones potentially results in the unnatural mesh deformations that need to be corrected manually. In Flash, we experienced problems in the area of elbows, where the black outline produced thicker areas, whereas the upper arm became too thin (follow Počtík to his house and let him point at the compote bottles).

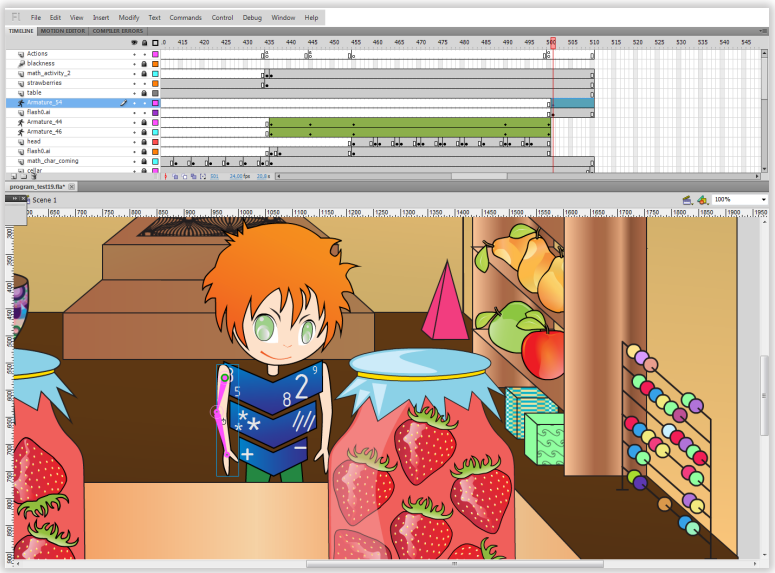
However, this problem can be caused by an inappropriate character desgn - if we had drawn the arms as connections of separate objects, this deformation wouldn't have happened (see the tutorial [51] for an example).

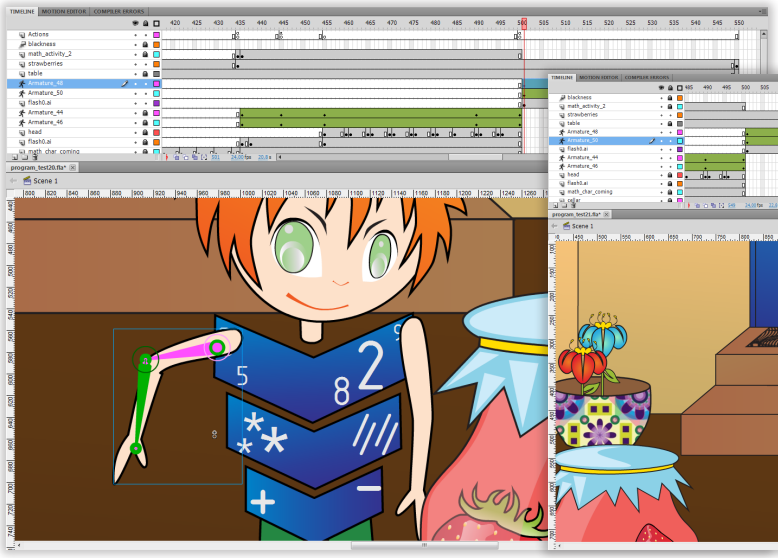
3.6.3 Sound

In the final application, each of the guide characters should have its own voice and read the assignments aloud for the children. Besides this talk, the program should also offer an appropriate background music for every scene to supplement the atmosphere and provide a complex experience. Also, adding a sound effect when some choice is made within the activity is also a good idea, as it provides an extra feedback for the children.

The sound we incorporated in the prototype is on a very basic level and do not comply with the requirements we described above. To achieve an appropriate result, a specialist in the field of music should be consulted, recommending an appropriate music for each of the scenes and actions. As we wanted at least to provide some simple sounds to the prototype in order to be able to test the perception of their presence, we decided to simply use parts of some songs, employing a shareware program called GoldWave for editing.

The music we used in the intro was taken from a song called *Ants Will Survive* by Shayning, because it suggests a playful atmosphere full of joy and hope, and we extracted another tone from this melody to obtain a sound used as a selection and





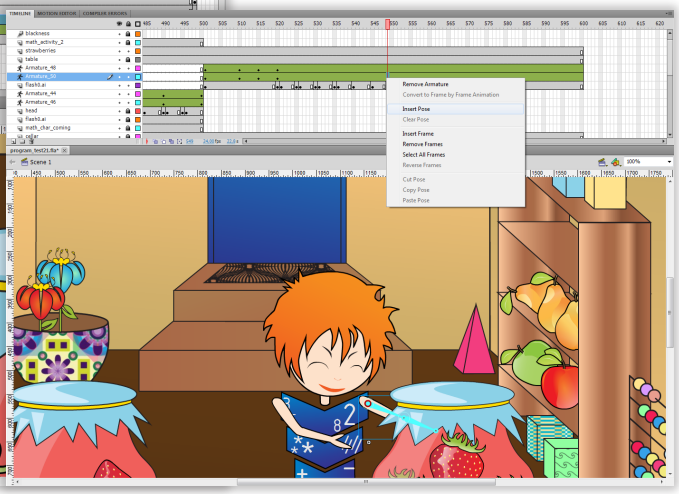


***Figure 50 (left), 51 (below left) and 52 (below right)**: Drawing bones on an element - such as an arm - results in the creation of a new, green-colored layer called "Armature" on the timeline (Figure 50). The objects with assigned bones can thus be manipulated through the bones' joints (Figure 51). To achieve an even more natural movement, it is possible to adjust the ease of the movement and restrict the angles within which the joints move the bones, approaching a real-world human motion. To ensure that the objects will take on the same original position at the end of the movement, Flash allows to insert a pose in the keyframe, returning the character its initial posture (Figure 52).*

confirmation feedback. In order to acquire the wind blowing sound for the intro of the fundamental mathematical concepts activity, we extracted the intro of *Starbeam Antarctica* by Psyborg Corp. We need to emphasize that the sound concept of the application needs to be developed further and consulted with a musician - the songs we used are not appropriate for such application.

3.6.4 ActionScript 3.0

Even though we can achieve some sort of interactivity by entering the buttons sub-menu directly from the stage and assigning sounds or visual effects to the Button symbols, creating an interactive movie clip requires the use of a scripting language. ActionScript is actually an object-oriented programming language similar to JavaScript, and allows the creation of event listeners or timeline navigation to name a few.

The syntax of ActionScript is not complicated, and thanks to the big community of developers there are many tutorials and examples available online. In Flash CS5, there is also a possibility to make use of the pre-prepared code snippets that are sorted according to the type of interaction they handle. Thanks to the simple nature of our application, there was no need for any complicated programming and we used ActionScript mainly for the timeline navigation.

To keep the timeline organised, it is best to create a separate layer uniquely for the actions (in the prototype.fla enclosed on the CD, the layer containing ActionScript code is the one at the very top called "Actions"). ActionScript can then be added to whichever frame of this layer on the timeline: such frames are then labeled with a small cursive "a".

In ActionScript 3.0, code cannot be placed directly on objects, but the code snippets can be applied on the current selection on stage. This way, it

is possible to create timeline navigation in a really quick way - although we still have to pay extra attention on the frame numbers to achieve correct animation sequence. When employing ActionScript, we also need to name properly the instances and other symbols in question to ensure that the code will be assigned to the object desired.

3.7 Interaction design summary

We tried to grasp the complex nature of preschool children centered interaction design in this chapter, and developed a prototype following the guidelines arising from research and observation. The prototype doesn't represent any refined application: it was made mainly to allow testing with end users and find out whether such way of working with preschoolers is possible. We will focus on all the interaction design rules applied also in the following part, where we will discuss the outcome of test sessions and evaluations, drawing the emerging consequences for the prototype.

However, we would like to present a set of recommendations for children-centered interaction design right now, as these represent the absolute basis and specialists have agreed on most of them; these rules don't represent any complete list though, and should be adjusted according to the target group's preferences and abilities if necessary:

- observe the target group during an activity that is as similar as possible to the one the application is focusing on; such observation reveals important facts about users and their customs that usually cannot be acquired otherwise
- try to design the interaction in a way that is comprehensible and enjoyable for the children: use tangible interfaces or any other sort of interaction that allows children to be part of the action: keep them engaged
- map children's actions to the actions happening on screen in a way that is as direct as possible or provide a clear parallel
- do not force children to use adults' routine concepts that can be unclear or tiring for children, resulting in leaving the activity
- allow children to experience the events on screen with more than just one sense: use sound to accompany the action in an appropriate way
- sound can also help to present the instructions necessary to accomplish the task given
- objects that allow interaction should be clearly identifiable and easy to manipulate: provide hints concerning functional elements
- an immediate feedback following children's actions need to be provided, be it a visual or acoustic one
- make sure the feedback provides children with enough praise after a task is successfully finished
- the interaction should be simple and easy to remember: children should not be forced to learn how to control the application so that they can focus immediately on the educational tasks presented
- in case of an application focusing on education, make the interaction easy in terms of physical effort so that children can focus on learning
- do not use navigation in a form that is typical for adult users; replace menus and submenus with comprehensible images or understandable visual metaphors.

According to the main cycle of work that should be followed while taking the user-centered design process into consideration [23], we fulfilled another - this time the third - step:

- create design solutions: this part of the process may be done in stages, building from a rough concept to a complete design.

Starting with the most basic rules such as color theory and young children centered illustration, we designed four guide characters and remade them according to the children's comments (see Part III for more details). Settings and a sort of "back story" have been suggested so that they comply with the assignments proposed in special publications, yet take on a game's shape.

To learn more about operating the prototype, see Appendix 2; to find out more about the way we tested our protoype, continue to the Part III on the following page.

Part III: Testing

Chapter One: Testing with children

To find out whether the application we designed complies with the requirements of the target group, it is necessary to proceed with the usability tests; these immediately reveal whether the design is understood in a way it is supposed to be [6]. The most reliable methods consist in testing with the target group users, and can quickly reveal a considerable amount of information concerning how is the application really used [6].

1.1 Arranging a session with children

In our case, testing with the target group means involving the preschool children directly in the usability tests. As we have already mentioned in the previous chapters, getting children to provide a feedback on an application (or any sort of new design in general) is rather difficult. There are ethical reasons that make usability testing with children nearly impossible, and we were thus limited to our acquaintances who had children they were willing to let see the prototype.

The problem is that parents tend to be suspicious and reluctant when hearing about their child being exposed to a work of someone they see for the first time and don't know anything about. With all the contemporary issues including mental development of children, parents got frightened of letting their children see any kind of inappropriate content - which we can't hold against them considering the present situation. Discussing suitability of such parental behavior is beyond scope of this text, but the conclusion for us is clear: finding participants from the target group is nearly impossible. While visiting PPPs, schools and a kindergarten, we became aware that the theme of our work suggested we were studying psychology, teaching or even special education - and hearing we were not meant that specialists feared our lack of knowledge concerning ethics and conduct. This could have also contributed to the general suspicion of our work.

Another issue concerning testing with children is something we didn't realize at first: it can be unimaginably hard to get the information from preschoolers, as they are not like adults, and it is not natural for them to express their feelings about something like an application design in a clear way. They don't (and even can't) judge the prototype from the same points of view adults do, tend to neglect issues adults would look into, and pay attention to details adult users might label as irrelevant. Also, as they have little experience with controlling an application, it is not easy to find some sort of comparison or parallel we could hold onto in order to obtain - and later interpret - an applicable information. It may sound obvious, but many issues of similar sort simply don't show up until the test setup is being prepared, or the test session is in progress. It is important to keep that in mind, and don't get upset during the session. Preparing a test session guide with points we need to get feedback on is necessary to keep track of what has already been asked and what still needs to be discussed; however, we should be prepared to skip in between the themes according to the user's actions: their order can contribute to the findings considerably as well.

In order to involve the target group in as much testing as possible (which is necessary considering the iterative nature of our design process), we had to be creative and employ current trends such as online appraisals. The finished prototype was then tested on two children from the target group. We also seeked feedback from special educators, kindergarten teachers, psychologists and parents, as the prototype should also comply with their idea of educational application. We will discuss the feedback from adult users in the next chapter.

1.2 Motives and tests' set-ups discussion

Before we start planning a session, we should always have a clear idea concerning what do we intend to find out with the testing, as the fashion of arranging sessions and requirements on the prototype (or other tested materials) depend on it greatly. First we need to know why and what do we need to test, and then we can develop the session guide and look for suitable participants. The nature of the tested material also influences the way it needs to be tested: today we don't have to rely solely on the meetings with participants, but we can make use of remote sessions as well.

Clarifying the points we needed to get feedback on, together with considering our poor accessi-

bility to the target group led us to establishing tests online on a social network. The main advantage of such tests is that people who know children from the target group also know us and the issues concerning impropriety are thus insignificant. Moreover, such people represent a reliable source of information for us (they are trusted friends) and they can ask children when opportunity permits, so that children are in a good mood to comment the designs.

At the early stage of graphic design, we needed to find out whether the characters we established looked attractive to the children. As they are going to guide the preschoolers through all of the activities, we needed to make sure children accept them well. So we put the picture of Budík, Pamětka, Krychlička and Počtík online (see Figure 53), without revealing their names nor the activities they are associated with. Our questions were very simple and straightforward:

- would the children be willing to play with any of these characters?
- who looks the most friendly to them and why?
- is there anything they consider weird?
- what kind of games would the children associate with the respective characters?

As it was a Sunday afternoon and the weather wasn't very good, we soon got some valuable comments from friends who had preschoolers around.

Another set of pictures we got the feedback on this way concerned the activity related to basic mathematical concepts. We had just finished the main story with the assignment and created graphics components including strawberry compote bottles between which the children were supposed to pick the one containing more strawberries. As we weren't able to talk directly with children when developing the visual style, we were afraid whether the graphics of key components prove to be comprehensible for children. We also needed to test the facial expressions of the guide character when announcing the feedback on the children's compote choice - he should not look frightening while explaining the choice was wrong, nor look unnaturaly happy if the choice was correct; still, these looks needed to be clearly distinguishable and depict the judgement precisely. So we put online Figure 54, and asked the following:

- can children count the strawberries through the glass reflection?
- do the strawberry compote bottles look alright to the children?
- is the character's expression evident?
- is the character's expression appropriate?

Even though the tests online were effective and we gained invaluable findings, we needed to test a functional prototype so that we can get a feedback on the interaction design. Showing the animated version of the application also proved to be necessary as we got some negative reactions to the *double-headed* character on Figure 54 - children (and some adults too) did not grasp the two heads as an approximation of head shaking, but thought the character was some kind of a "weird freak".

Besides testing the interaction design, we were also curious to see whether children develop any sort of "relationship" with the guide characters: are they going to perceive them as tutors, since they judge their answers, or will they consider them friends since the characters invite them to play together?

We also wanted to see how children react to the animations included in the prototype. As special educators claimed, preschoolers generally like moving graphics, but also get bored sooner than older children, and excessively long animation isn't a good idea if we expect it to repeat often. In order to avoid these risks, we created only short, simple clips - but we weren't sure whether they aren't *too* short, as we wanted to employ them also as a reward for successful completion of a task. We thus needed to ask the children if they understood well what happened and if they think it was appropriate considering the situation given.

1.3 Online appraisals

The online appraisals we obtained were, except for the two-headed monster character, very positive; surprisingly, we got some feedback also from our adult friends and some of them even sent us detailed mails with the comments of children whose parents didn't agree with the publication online. In total, we got feedback on the character design by five preschool children, two girls and three boys, aged from four to six. Most of them would go and play with at least two of the characters.

The feedback on the character design was crucial especially for Počtík, guide for the fundamental mathematical concepts activity: compare Figure 53 on the page opposite and Figure 33 on page 28. Počtík's hair was judged weird by a five-years-old boy, but this negative feature was overriden by a positively judged fact that "he is hold-

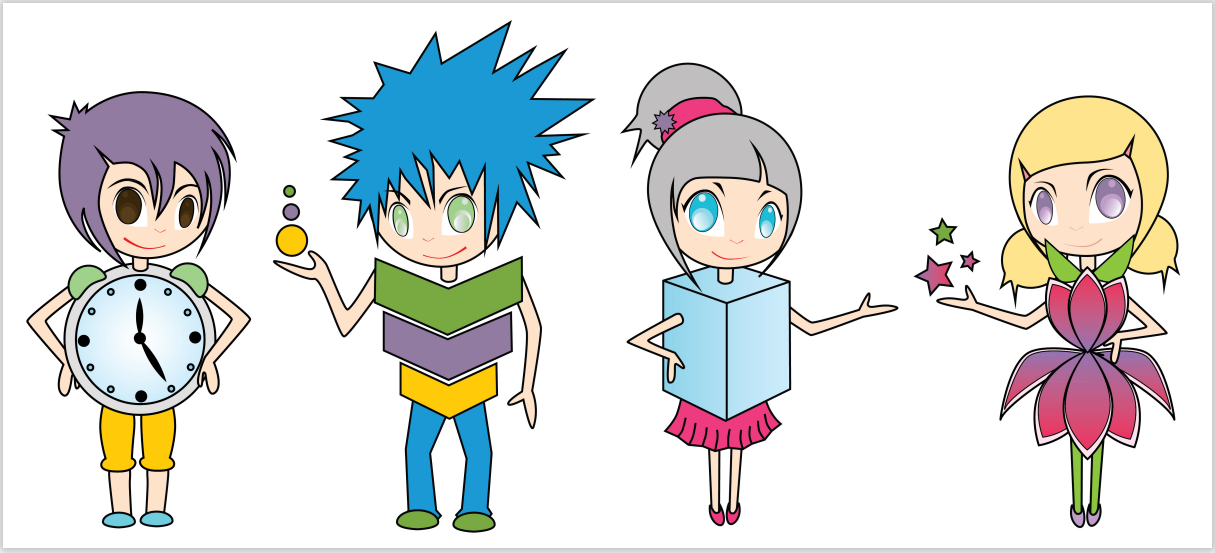


***Figure 53**: The very first version of the guide characters we tested on the target group. As the tested material was still just a static picture and the information we looked for was clearly defined, we opted for an online testing.*

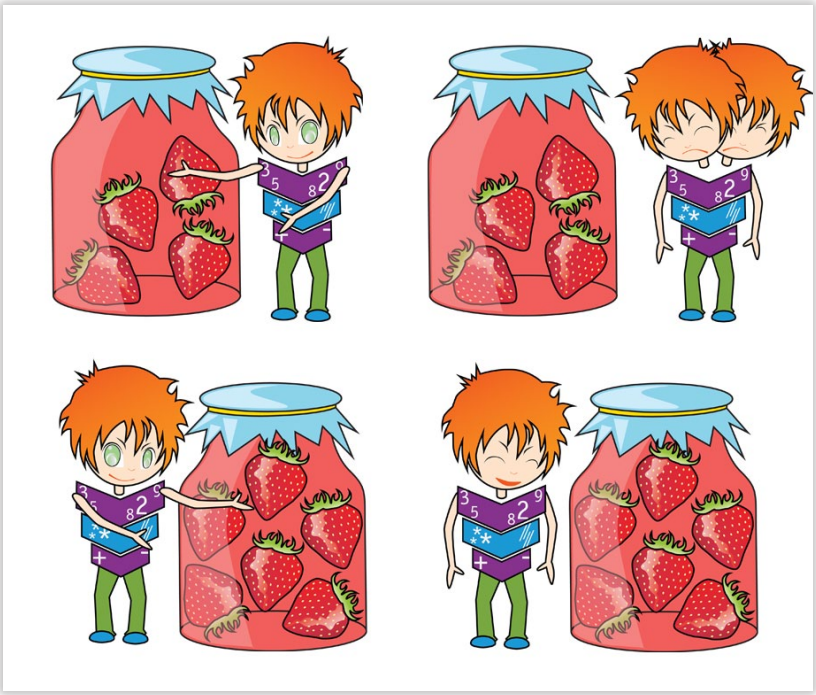


***Figure 54**: Artwork supposed to test the comprehensibility of the strawberry compote bottles and the "countability" of their contents, together with the facial expressions of the guide character. The strawberries were perceived positively by wide scope of people including the target group, while the two heads of the character immediately provoked negative emotions, as the concept of "static head shake" wasn't obvious. Note the difference between the look of the guide character on the image at the top and the one on the left; the latter represents a second version, based on the feedback we got on the first one from preschool children.*

ing a weapon" (the three color circles). A six-years old girl claimed that Počtík's hair were "downright ugly" and she said she wouldn't go play with such character. On the other hand, another five-years-old boy judged such hair as attractive and called Počtík "blue thorny". Concerning the activity children would associate with Počtík, there were no ideas at all. Počtík was also considered as the most friendly character by only one out of five participants.

On the contrary, Budík's activity was immediately clear to everyone, as the clock face on his trunk is pretty straightforward. A four-years-old boy said that Budík is "fine, because he looks like a robot" and another five-years-old boy even came up with a short story idea involving this character called "confused clock". Three other older children even observed it was five o'clock. Budík was labeled as a favorite character by two children, and all of those who participated were willing to go play with him - we presume because it was clear what sort of activity can be expected. An important finding was that the majority of children thought Budík was a girl because of the color and length of his hair.

We also observed a strong favor towards the characters of the same gender as the participant: when asked which character would he go play with, a six-years-old boy explained that "the two characters on the right are for girls, so they are out of the question", and all three boys chose male character as their favorites.

Krychlička was once associated with mathematics, otherwise it remained unclear as to which activity she could be connected. A six-years old girl chose Krychlička as her favorite character, just because she looked "nice". Two boys were completely uninterested in both Krychlička and Pamětka, but the third one suggested another story starring Krychlička, this time called "magic box fairytale". Except for one participant, the activity connected with Krychlička still remained unclear.

While completely omitted by two boys, Pamětka was immediately loved by a five-years-old girl, who thought she was a flower fairy. All the children connected this character with nature, so they expected some sort of biology-related activities; the five-years-old girl suggested she could perform magic as there were stars above her hand. The five-years-old boy made up another story involving Pamětka and named it "water lily fairytale".

Overall we were satisfied with such feedback, as the characters weren't completely refused by any of the children. At this point, we already knew that boys would prefer male characters and girls the female ones, so the outcome concerning the choice of the favorite characters wasn't so surprising.

On the other hand, we were stunned by the fact that Počtík was perceived as someone who held a weapon (and even more by learning that it was judged positively). Considering the unique sense of imagination children possess, we needed to accept the fact that they perceive objects in a way that differs completely from ours, seeing hidden context that existed solely within their fantasy.

Concerning the feedback on strawberries, none of the children had any difficulties deciding which bottle contained more strawberries. We were worried about the difficulty of the task so we arranged the strawberries in the bottles so that they were all entirely visible. It turned out that it was unnecessary, as the task was indeed easy. The six-years-old girl even examined the compote bottles carefully and said in a mentor's tone: "But you know, strawberries don't float in the bottle like that. They usually gather at one place, at the bottom of the bottle." This was obviously wrong, as fruits float as close to the surface as possible, but we were amazed at the girl's level of observation and thought.

As the double-headed character stole the attention immediately, we were not able to test the facial expressions thoroughly. On the other hand, even learning that we should not unnecessarily complicate the tested materials was a valuable feedback for us. As none of the children became scared of the character and just said the two heads looked weird, we decided to keep the expression as it was.

1.4 Prototype test session

When we finally had the opportunity to test the finished prototype on two children from the target group, a four-years-old girl and a six-years-old boy, we prepared the following list of points we wanted to look into:

- character design and the overall visual look of the application
- the way characters introduce themselves: do children even pay attention on what the characters have to say, or just select them according to their looks?
- animation speed and arrangement
- comprehensibility of the tasks given
- difficulty of the tasks given
- ease of interaction (is it intuitive and natural for the children to point on the screen?)
- children's willingness to fulfill the tasks given (is it fun for them?)
- parents' willingness to get involved in the activities with children

We didn't prepare any other special guide, because we wanted to follow the children's way of walkthrough and not a pre-prepared list which most probably wouldn't be followed anyway. We just made sure we knew what we needed to test and where (on which screen) we needed to ask about it if necessary.

The most important thing is to come to the test session with both eyes and mind open, because "even though we might focus on testing an existing interface or just a small part of it, the session can help us understand or discover factors and constraint that haven't been planned at the beginning or remained undiscovered until now" [40].

Concerning the equipment necessary for the session, we used an Asus notebook without any special features - Flash movies tend to be small in size and our prototype was enough simple to be undemanding regarding hardware requirements. As the test session was agreed to take place at the participants' home (which we welcomed, because children would feel more at ease in an environment they know well) and we didn't manage to gather information on their television, we also took a full HD 22-inch monitor and necessary cables with us. It is always better to be overly prepared than omit something crucial, what a full HD display unquestionably was. We also asked the children's parents about the reward we should bring for the partici-

pants, and bought two preschool-centered magazines according to their advice.

After the introductions, we explained to the children that we test our application, not their skills, and that if they don't understand something well, then it is a mistake of the prototype, not theirs. We also explained that all their impressions were valuable and important for us, so they don't need to worry about saying something wrong, and encouraged them to comment on anything that catches their attention.

The problem we didn't consider at the beginning consisted in the fact that children can be really shy when communicating with strangers - as all the feedback from the children we got until now was mediated, we didn't realize that it may be sort of awkward for the children to give and explain their opinion to someone they have just met. After a while, we realized that when it is a common rule to ask open-ended questions during testing with adults, it is actually better to ask closed-ended ones while talking to children who are shy. As we have learned during the observation of the preparatory courses, young children don't lie, so we weren't afraid they would confirm something they didn't mean seriously.

From the beginning, children's mother was present at the session and encouraged children to speak a bit more, helping them to overcame their shyness. She also provided us with comments that were important, as she represented opinion of parents.

The opening animation was generally well accepted, children were curious and looking carefully on the screen. Mother suggested we should make a path for Počtík's skateboard in order not to give bad example (he rode on the grass). She also thought that the amount of clouds on the sky was excessive, and that the scene was too simple: "Add some hills at the background". Children thought the scene was fine though (but maybe they were just shy).

The first character to catch the boy's attention was Počtík ("I would go and play with the boy who has orange hair"). We read his introduction aloud, and seeing the child continued pointing on the screen, we proceeded immediately to the first scene (windy landscape), skipping the confirmation screen. It turned out that children were pretty sure with which characters they wanted to play first, and the confirmation screen was, in this case, needless.

Windy landscape was perceived as too dark by the mother, and she also thought that leaves in the air meant autumn, yet the green colors suggested summer. The boy said he liked it.

The task with strawberry compote was finished very quickly: the boy pointed to the right bottle without hesitation and even added "the one on the right". Children seemed to enjoy the concluding animation, as they laughed, and the mother suggested we should place Počtík friends to the window of their house, so that the situation is clearer. She also thought the task was too obvious, and would prefer if children had to look for the bottles first.

Second activity was chosen by the girl: she picked Pamětka. Concerning the garden scene, when children were supposed to talk about what they see, we experienced again their difficulties with talking in a stranger's presence: the boy rather answered questions mother asked ("What do you see on the tree? What is it blooming on the ground?") and the girl didn't say anything, even though mother encouraged her. As we knew we had to be careful while working with children, we didn't insist and moved on to the task where a misfitting object should be picked. It was finally answered by the boy, again with no hesitation.

As the third children agreed on choosing Krychlička. They appreciated the animation ("jeee") and the boy said that there were many things in the room, but he didn't perceive it as bad - just on the contrary. Concerning the tasks given, they were again excellently fulfilled, and the boy pointed the objects and said their names immediately after we announced the instructions ("Bonbón!!" - "Knížka!" - "Míč!"). He didn't have any difficulties with orientation in the room, even though it was quite full with different objects.

At the end, children picked Budík. We noticed they were not especially excited about him, so we asked why. The boy explained the character was weird, because he had clock instead of a body. We think that the boy didn't like such obvious metaphor, because he wasn't upset by any other character's appearance (Počtík's body looks like a striped shirt, Krychlička might have a normal body under the box and Pamětka looks like wearing a dress). When we asked further, we realized children were unable to determine Budík's gender, and it might also be the reason why they didn't want to play with him (he made them unsure). We asked what should we change so that they would play with him, but got no answer, so we suggested we should change the haircolor and dress him in a shirt with clock print, and the boy agreed and said it would make him look better.

The time activity was a bit complicated, because even though the children knew the names of

the seasons and in which order do they alternate, they had difficulties naming the typical related activities. The mother suggested that we should put more images with the particular season-related activities on the right, as it will fill the screen better and also provide hints for the children. We learnt that they perceived winter rather as a season of snowmen than Christmas, and that summer means hot weather rather than holidays as they weren't used to the school rhythm yet.

All the activities were well understood and perfectly fulfilled; we concluded that the children were simply too shy to speak with us, and that was the reason they were silent during the time and visual perception activities.

At the end, we asked whether they enjoyed the session, and children said yes. The boy also claimed the tasks were easy, and his mother agreed. They also confirmed they would like to play some more, and asked whether more activities were available. As to which activity they liked the most, Počtík won - and after some more questions, we realized it was so thanks to the amount of animation (which was higher than in case of the other activities). Children claimed it was not too fast.

As to whether they would change anything except Budík we discussed earlier, children didn't know, but we saw them looking on the screen carefully and knew they truly couldn't find anything. The other characters were accepted well - children were not exceptionally excited about them, but they were still willing to join them in playing, which we considered good enough.

We found out that the boy didn't have any difficulties pointing on the screen to select objects (the girl was too shy to do so), but he always withdrew his hand very soon. We also realized that once he made up his mind, he didn't need any confirmation screens, because he pointed on the screen only after deciding which character to pick. Each character's introduction was thus read after he or she has been already judged and chosen based on his or her looks. Pointing on the screen proved to be a suitable gesture for choosing objects, but not so intuitive way to obtain more information. Children also pointed on the screen for a brief instant only.

At the end, we thanked the children and gave them their rewards - magazines. They were happy and thanked politely, and when their mother asked, they said we can come again sometime. So we think that they rather enjoyed the session, and only regretted they were so shy at the beginning.

1.5 Testing with children summary

While performing usability test with preschool children, we realized that finding participants actually wasn't the toughest task - the most difficult was to make them speak openly. Perhaps they would have been more talkative if we had met several times before and they knew us better, or if some of their friends were also present at the session - children are usually less shy and more eager to give their opinion when being in a larger group among people they know, as the children attending preschool courses tended to speak all at the same time.

We can thus conclude that we should have started with looking for participants as soon as we got this project assigned, develop a tighter relationship with the kindergaten (or with the school offering the preparatory courses) and organise some sort of "explanatory sessions" for parents, asking them permission and offering to look on the prototype beforehand, as well as being present during the test sessions. This would require much more organisation (maybe including some official paperwork), but maybe it would have allowed us to show the prototype to more children at once, in an environment they were used to (nursery class), and provide us with more findings.

On the other hand, we think that we were able to find out some valuable discoveries even during the session described above; for instance, we found out that children actually don't need confirmation screens, because they decide quickly and don't go back on their decision (we had this impression also while being present at the preschool course - children never changed any details in what they said, and seldom employed erasers while drawing at the enrolment).

We can also confirm that children like short animations combined with interactive tasks, as they watched the screen carefully each time an animation took place, and the boy was always eager to fulfil the assignment, looking happy (smiling) whenewer he was praised for finishing a task successfully.

To compare the children's comments with these of adults such as special educators, psychologists and other parents, see the following chapter; continue to Chapter Three for the interpretation of the findings we acquired in general.

Chapter Two: Expert reviews

As it proved to be complicated to test the prototype directly on the preschool children, we acceded to a less reliable group of testing methods called inspection evaluations. This group of methods includes heuristic evaluations, expert reviews and cognitive walkthroughs [52]. As such methods don't involve users from the target group, it is advised to use the results of inspection evaluations cautiously, as they tend to identify usability problems that can then prove not to be so striking [52].

We chose expert reviews as another method of testing the application because we wished to get the application approved by specialists from different fields. First, we needed to identify potential issues from the psychologists' point of view, so that the application can be accepted as appropriate for children. Second, we needed opinion of special educators and teachers, who can judge the educational content of the application and its suitability for preschool children. As we mainly focused on the visual aspect of our work, we also wished to get some feedback from people who have a degree in art, and discussed the application with a graphic designer and high school art teacher.

Most of the specialists we discussed the prototype with already had children, so they were able to provide feedback from the parental point of view as well. Before starting the session, we explained our motivation, purpose of the prototype, and clarified the setup our application was designed for: full HD television connected to Kinect (we tested again using computer and full HD monitor).

2.1 Psychologists

Talking with two psychologists provided us with valuable information concerning understandability of visual metaphors used in the prototype and of the information's consistency in general. As we showed the prototype to one of the psychologists before testing it with children, we were also able to acquire some tips concerning how to ask children to get the feedback necessary.

Concerning the main screen, we learned that the characters should not remain still once the animation is finished, but should wave at the children to catch their attention; as children return back to the main screen after completing an activity, characters that haven't been chosen yet should wave even more than others. Animation in general wasn't judged too fast, just on the contrary: it is good that animations don't keep children on the same screen for a long time.

As the other psychologist had a child aged four, she said her daughter would immediately love Pamětka, considering her fairy look and flower-like dress. This confirmed once again gender preferences. Also, she said the scenes are well arranged and it is pleasant to look on them, because the colors were nice and engaging for the eyes.

We were especially curious about the feedback on visual metaphors, because we felt they are not as obvious as they should be. We were told that both Krychlička and Pamětka are holding something strange, and children could be puzzled by the two characters having such things in their possession. It was pointed out that it is better not to give them anything instead of making them hold some strange object. Providing children with two strong incentives, such as a flower dress and layered star as in Pamětka's case was judged to be too much.

Concerning the confirmation screens, we had put there pictures we found appropriate, but their connections to the theme were judged as too complex to be grasped by a preschool child. For instance, to visualize the time going by, we put three bananas in different level of ripeness on the confirmation screen next to Budík. We were told it makes allusion to mathematics rather than time perception, and were advised to put a simpler metaphor on there, such as a visualization of day and night.

As to Krychlička's confirmation screen, she should be surrounded by something that is connected to the left-right orientation, such as two hands. Pamětka had flower patterns on her left side, which were made up of geometric components on her right side. The shapes were judged too complex for the children to understand the connection. Finally, Počtík's screen should make a clearer reference to mathematics, and we were advised to use fruits of the same kind to avoid confusion.

The fact that a soundtrack wasn't added to the prototype was perceived as negative, and the psychologist explained that it would be better to

keep the sound of characters' voices on even in case parents were working together with their children to maintain the difference between the voices.

From the psychologist's point of view, the application was judged as a good tool for children, because "it doesn't disturb their childish world and provides a nice resource of themes to be discussed for parents". There was a suggestion of distributing a special manual for parents to follow together with the application, providing them with hints concerning what objects to focus on and discuss further with children. For instance, in Počtík's front room, parent should make children understand that fruits can be conserved in bottles over the winter, and on the screen of Pamětka's garden, the difference between edible and poisonous mushrooms should be explained. If such handbook was created, soundtrack was provided and some of the visual metaphors were improved, then the psychologists wouldn't have any further objections.

2.2 Special educators and teachers

We discussed the prototype also with special educators from PPP for Prague 7 and 8. They confirmed that sound was an absolute necessity for such application, and agreed with the psychologists that keeping different characters' voices would be better than making the same parent read all the assignments in the same voice.

The special educator observed that the prototype looked really interesting for children, including colors and graphic style. She said she noticed children prefer clear pictures with objects they can recognize easily, and so the application should be accepted well from the visual point of view. The second special educator we showed the prototype to liked the graphics as well, observing that "the colors are very nice and pleasant, and bright but not flashy". She also complimented on the layout of the elements on the screen, and suggested that the seasons discussed within the time perception activity could be enhanced with talking about the customs related to each of them (Easter, Christmas), accompanied with the appropriate pictures.

As we went through the activities, the other special educator pointed out that the exercises are designed very well, as they aim to develop children's skills in many different ways. She also liked how the activities alternated even within the same category (Pamětka first asks children to describe the picture and then makes them select the misfitting object in the row) and thought it was the right way to maintain children's attention. The other special educator said that the backstory can enhance the activities in an important way, as there are not so many programs employing such scheme.

We also learnt that concerning the number of activities children can take on in a row is around five, and that these shouldn't take longer than about fifteen minutes in total. Preschool children can't maintain attention for too long, and quarter-hour is an appropriate amount of time for them. As we planned to provide a sort of backstory to each of the characters at the beginning, we were interested in whether children would be able to grasp a concept of more activities following one another and forming a storyline together. She said that children might like the idea, but that we need to be careful and design the activities in a way that makes it easy to resume the task from the point it was stopped, reminding the children what was happening.

As a nursery school teacher pointed out, the number of activities and their difficulty levels depend solely on the child that takes them on: for instance, even dividing activities into age-based categories wasn't perceived as convenient, because each child is different and the process of learning should be adjusted to its individual needs. For instance, the space perception activity was judged to be too difficult for most three-years-old children, and the strawberry compote activity as well. On the other hand, one of the special educators thought that the space perception activity was appropriate for children aged from three to four and suggested we employ five objects in case of six-years-old children. She also proposed a variation of this activity in which the recognized objects disappeared after being marked by the child, and appeared at the end with one extra object that the child was supposed to recognize ("find the object that wasn't in the room at the beginning").

We also asked about the rendered scenes in the nursery school, and while comparing them to the ones produced in Illustrator, the directress said the latter look much better and friendlier to the children. She also confirmed the proper choice of colors, claiming that "it looks like I envisioned it."

Both special educators thought that we should recommend parents to follow the activities by the children's side: one said it would contribute to the parent-children communication, which she perceived as very important, and the other one wished there were more enlightenment opportunities to present this issue. On the other hand, they agreed on admitting that if a child is not mature enough to start the school attendance at the appropriate age,

even taking on such exercises won't help. One explained she saw many clever children who had their school attendance postponed because they were unable to maintain attention - and since this is related to the development of the central nervous system, there are simply no other ways than waiting. The other special educator explained that forcing a child to start school attendance too soon may result in failures which can burden the child for the rest of its school life.

The interaction based on pointing was found original, but one of the special educators thought that children aged five and six won't have any difficulties controlling the application with a mouse. Pointing at the screen was judged appropriate for children aged four. The other special educator saw future in employing iPads for such applications, but appreciated the idea of using Kinect as well, as it was judged simple yet intriguing.

In general, we obtained a very positive feedback - one special educator said she liked the prototype very much and thought it could be found useful by parents of the preschoolers. She also said that there are a lot of games available for children at present, but their goal is just entertainment and not education, which she judged as very negative. As to the fact that the application was designed for televisions, the special educator didn't find it inappropriate in any way. She explained that television and computer can be of use for children, but parents often just put their children aside in front of a screen to gain some more free time, not caring about providing the children with educational activities instead of senseless games.

The other special educator had the same opinion on employing devices such as computers and televisions for children-centered applications and even favored their use. She also suggested that keeping statistics would be a convenient feature, especially if it would be possible to print them out in an appropriate format.

Another improvement she suggested was integrating one more activity, this time centered on graphomotorics. She explained that such area could embrace wrists-centered relaxation exercises that would be helpful for writing practice. However, she then pointed out that she liked the four characters we designed so much that she would just "keep it as it is". Obtaining such feedback can happen often while testing the high-fidelity prototype.

A very pleasant surprise was that she offered us cooperation and insisted on further extension of the prototype which she liked a lot: "The graphics is amazing and it should be used in practice." We were glad to hear that especially because this special educator, Mgr. Jaroslava Budíková, was a co-author of a book we referenced in the literaure list for this thesis.

While attending the preparatory course for preschool children, we also had the opportunity of discussing visual design with the primary school teacher. She liked the guide characters a lot, and confirmed the popularity of such child-face-like designs among children.

We also discussed the concept of "find the object that doesn't fit in row" activities, showing her some examples we made (see Appendix 3). We wanted to know whether children determine the misfitting object according purely to its nature, or whether we risk to influence the child's decision by making some objects in the row bigger or inclined. She explained that we shouldn't worry about such sort of influence, as finding out that a child selects the misfitting object according to a different clue than expected can help to reveal some issues concerning its perception.

2.3 Artists

As we emphasized at the very beginning, we focused mainly on the visual aspect of the prototype, and put much thought to the design. At the present, countless drawing and animation styles compete for children's attention and liking - so we wanted to know what do specialists with degree in art think about the visual side of the prototype.

Both of the artists we talked to liked the style, and thought it would be appropriate for children as well as interesting to watch for parents. They also agreed on the pleasant choice of colors; the art teacher appreciated especially the shades of green employed in the garden scene. The simple level of animation was found satisfying: the teacher said it depicted the situations in a clear way, and the graphic designer observed it must have taken a lot of time to create all the short clips. They both liked the setting and found there were a lot of objects for the children to look at.

Despite the positive feedback on the overall style, artists confirmed some issues with visual metaphors: Budík and Počtík were connected correctly to their areas of activities, but Pamětka nad Krychlička were mistaken for natural history and stereometry. The characters were labeled "interesting"and "cute" though, and the teacher pointed out that "in my opinion, as long as the characters look attractive, children should be willing to play with them." When the graphic designer said that he had a son

aged four and that he would "be happy to provide him with such application", we felt that this is the best feedback we could have gotten.

2.4 Expert reviews summary

Looking for experts to evaluate our designs proved to be less complicated than involving children, because we talked mainly to specialists we approached already at the very beginning during the research phase. After we explained that we didn't need them to write any kind of assessment concerning the prototype and we needed their feedback because it was a diploma thesis project, they were very co-operative and interested.

Even though we were well aware that expert reviews have their limits, we were glad to be able to discuss the prototype with specialists across domains - their comments brought suggestions we could have never obtained from children themselves. As we tested the interaction design directly with the target group and have already identified problems in this domain, we wanted to obtain expert reviews in order to get a completely different sort of information; we wished to find out the suitability of the application and its level of general contribution to the children's development. We also talked to specialists because they had considerable experience with similar programs.

In general, the feedback from specialists was positive, and we were able to confirm that while such application doesn't need any elaborated animation, sound track contributes to its success in an essential way. The application was welcomed as a tool that not only provides children with valuable educational activities that improve and develop their skills, but also induces parents-children communication, which is perceived as extremely important. As we obtained some positive responses also from parents who liked the overall look of the prototype, we can hope that such application would be interesting even for adult users. This condition should be fulfilled so that parents are willing to be present at the educational activities of their children.

Chapter Three: Results interpretation and design outputs

According to the iterative design process, we should incorporate the appropriate changes into the prototype after evaluation, and then test it again. In this chapter, we will describe the procedure of interpreting the findings and incorporating them into the design of the next prototype version.

3.1 Character design

After going through all sorts of children-centered illustrations and establishing our own four guide characters, we evaluated their design for the first time. As the character who received the most negative feedback was Počtík, we decided to make changes especially to his hair (perceived as "downright ugly"), make him look more mathematics-related ("I am not sure what should we play with this character"), and replace the three circles in his hand with different geometric objects ("he is holding a gun") - see the previous chapter.

First, we transformed Počtík's spiky hair, and gave him a neat coiffure. As we wanted this character to stand out and catch children's attention, we changed the haircolor to reddish orange. We also reduced the number of color shades used on Počtík, and traded them for saturation: as we have already used orange, we omitted the yellow and employed a more vivid tone of violet. We made one more step between the first evaluated design and the final one, see Figure 55 below.

The appropriateness of the changes we made to this character was proved by his success during the prototype test session, when the preschool boy wanted to play with him straight from the start and labeled him his favorite at the end of the session.

We also made little changes to Krychlička: she was given an imitation of coordinate system origin, but it was more out of necessity to make her stand out than make the visual metaphor more obvious, as we don't expect children to know about such things before entering school.

We thought that Pamětka was associated with biology and natural history because of her flower-colored, flower-like dress (which is really partly made from a flower artwork, without making any changes to the original colors - see Appendix 3). We wanted to emphasize the symmetry and not flower pattern, so we decided to make the color of skirt different from the bodice. We also placed the 10-pointed star, made of the supersposition of two five-pointed stars in her hand. We believed that even though children surely won't notice this connection at the beginning, they might realize it later, after becoming familiar with the characters some more. See Figure 56 on the following page.

After showing the prototype to children, we regretted not tweaking the time perception character more fundamentally. As he was chosen as the most friendly-looking one by the majority of boys we consulted the designs with, we didn't pay enough

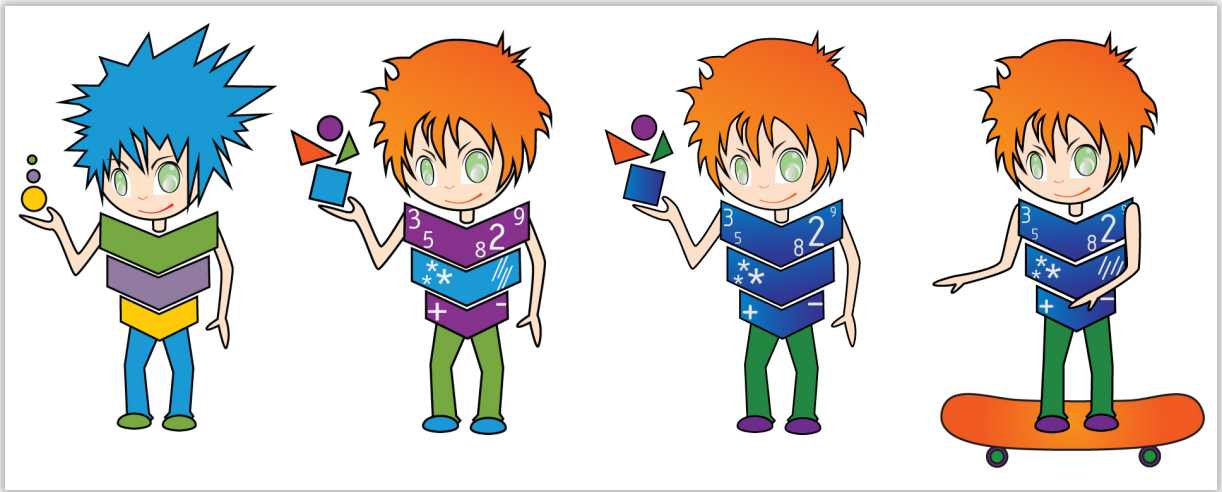


***Figure 55**: The evolution of Počtík, guide character for basic mathematical concepts. From left to right, it is possible to see the changes in hairstyle and color design. We also put numbers and mathematical operators on his trunk to make his connection with maths clearer. On the right, Počtík as he enters the main screen of the application.*

attention to the fact that children had difficulties putting him in the appropriate gender group. At the time, we didn't realize this uncertainty can lead to abandonment of this character, considering him a freak. After talking to the psychologist, we realized that we should shorten Budík's hair and change the color to light brown to make him look more boy-like. It also turned out that while the clear visual metaphor worked well with some children, making Budík look attractive for them, it was too much for others (see the section 1.4 of the first chapter in this part). As we have already suggested during the test session, dressing Budík in a shirt with clock print would be a more acceptable variant.

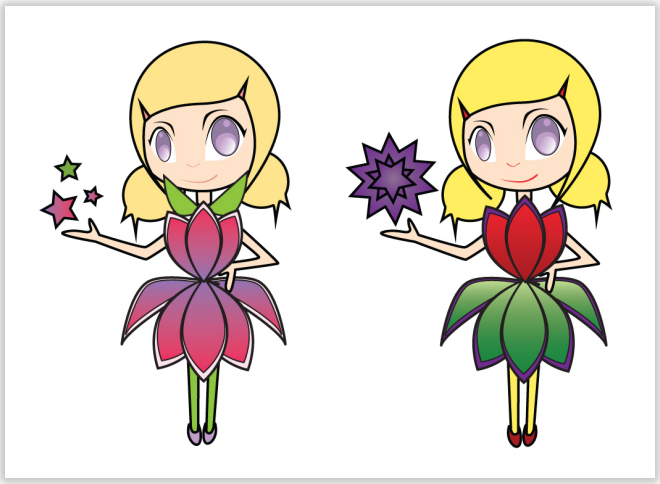


***Figure 56**: On the left, the original design of Pamětka wearing flower-like dress; on the right, we tried to correct the design so that it wouldn't suggest biology in such obvious way.*

3.2 Confirmation screens elements

When we discussed the prototype with the psychologists, we were suggested changes in the confirmation screens that would make them look more related to the activity field. It is possible to compare the originals with the redesigned ones on Figures 57-64 on pages 58-60. The changes they suggested were pretty straightforward and clear, so there wasn't any need for interpretation: we just altered the visuals.

As a next step in the redesign process, we should also consider more accurate specification of the upcoming activity; now all the characters simply invite children to play. We should establish messages suggesting the nature of the activity, such as "Now we will go and play with numbers together" in case of the fundamental mathematical concepts character guide.

***Figure 57**: Original confirmation screen for the time perception activity. We intended to visualize the flow of time by showing banana in different levels of ripeness and smaller and bigger flowers.*

3.3 Interaction design

Concerning the interaction design, we came across two problems: first, children point at the screen only after making up their mind, and second, they tend to withdraw their hand almost immediately.

As we have already observed in the first chapter of this part, children grasped well the idea of pointing directly on screen, but they only did so after making the decision, so our idea with revealing more information as children point to the characters didn't work. One of the solutions might consist in adding spoken instructions to the end of the intro such

***Figure 58**: Redesigned confirmation screen for the time perception activity. We decided to discard the fruits after talking to a psychologist, and use the alternation between the day and night as a better understandable metaphor for the time perception. Note that the elements on the new confirmation screen also fill the space more, so that there isn't so much idle space around the message.*

***Figure 59**: Original confirmation screen for fundamental mathematical concepts: elements are placed on the screen more or less randomly, to fill the space around the announcement.*

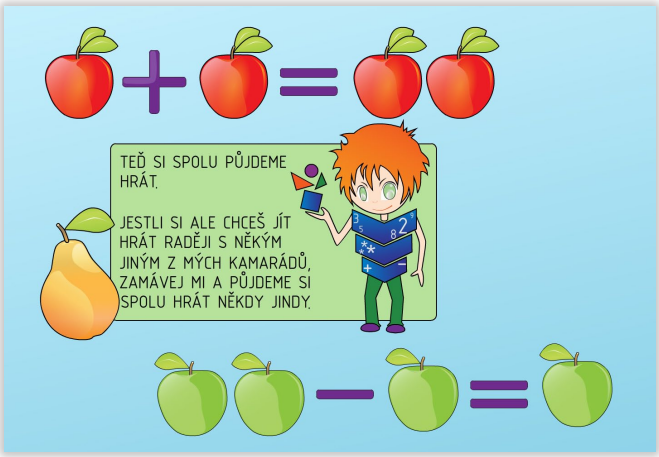


***Figure 60**: Redesigned confirmation screen for basic mathematical concepts. The connection with maths is more obvious.*

***Figures 61 and 62**: Original and redesigned confirmation screens for visual perception. The difference between lemons is more apparent thanks to adding a second coding: their faces.*

as "point to the characters to learn more about the games they would like to play with you!". As the prolonged pointing isn't likely to happen (children withdrew hands immediately), we need to find a better solution. In the next version of the prototype, we should try to introduce the guide characters simply one by one: for instance, Krychlička arrives the first, and as the cloud stops, she starts waving at the child and introduces herself as well as her activity. Then another character arrives and follows the same procedure. After all the characters introduce themselves, they continue waving and children are supposed to make their choice; pointing on a character will immediately lead to its confirmation screen. As the boy choose the character to follow definitely already at the main screen, the confirmation was not used at all during the test session. This new way of choosing the guide character will also be less tiring for children, as it doesn't require holding hand in the air for long. The application should also provide some sort of "cursor feedback": if a child points at the screen, a mark big enough should appear, indicating the place being pointed. Such feedback is a common practice in Kinect games.

There is also another important issue we didn't have opportunity to test and solve because of the nature of the prototype: returning to the main screen before finishing the activity in progress. We believe that waving can be an intuitive gesture for return, similar to the back button on mobile phones. If waving is detected, the activity in progress should be stored and children would return to the main screen. If the waving continues, the application will close. Upon the next launch, we should ask (using the appropriate visual metaphors, such as the guide character of the activity in question) if the child wants to continue with the activity in progress or start from scratch, including following a different guide character.

The last interaction problem we identified during the test session was absence of a gesture that would move the storyline within activities forward. For instance, when Pamětka asks children what do they see in the garden, we realized a gesture is needed to proceed with the second part of the activity. We thus came up with the idea of clapping hands: while announcing the assignment, Pamětka can mention that children (or better their parents) are supposed to clap hands in reward for such a

nice narration.

In general, it turned out that using Kinect for controlling an educational application is possible, as both children and specialists accepted it. On the other hand, what we tested was only a *prototype*, so we suggest further research and test sessions with children concerning the understandability of such control mechanism.

3.4 Activities and their backstory

As the most loved activity was the one involving Počtík and children revealed that the reason was the amount of animation, we can assume that they would welcome to get a similar, simple backstory for each of the characters involved. For instance, Budík just asks children to talk about seasons, but that's what any other person can do as well, so that may be why this activity wasn't popular. Krychlička is somewhere halfway, when she explains she searches three objects, but the children are not told why is it important to find them.

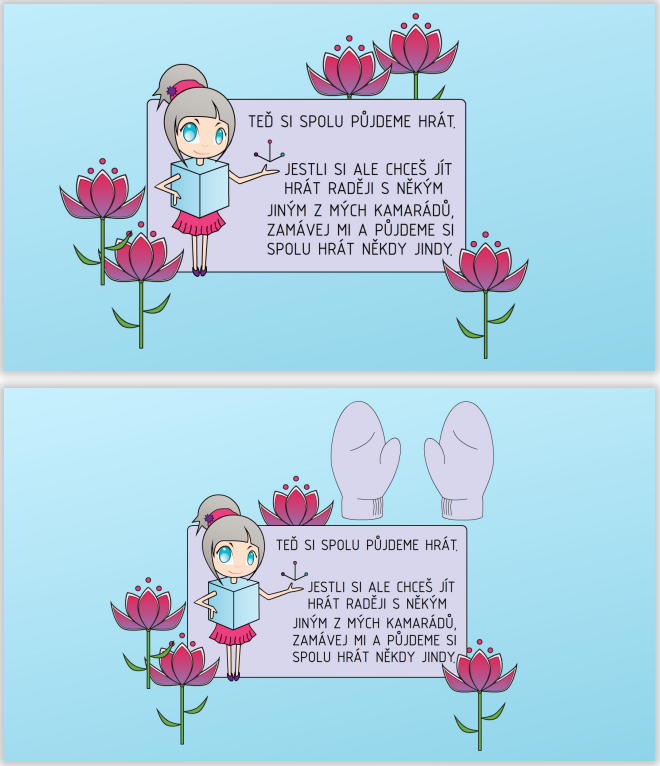
We thus believe that each character should be supported with a simple, yet clear backstory based on principles children could identify with, resulting in a strong motivation. According to the special educator, children might find this more complex structure of the activities appealing, and we think that it can make them feel like finding themselves inside a fairytale. After all, providing user with an invented environment and offering him to be a part of storyline are the main principles of role-playing games that are so popular nowadays - both among children and adults.

3.5 Design outputs summary

According to the main cycle of work that should be followed while taking the user-centered design process into consideration [23], we fulfilled its last step:

- evaluate designs: the most important part of this process is that evaluation - ideally through usability testing with actual users - is as integral as quality testing is to good software development.

The test sessions we conducted with our application's target group - preschool children



***Figures 63 and 64**: Original and redesigned confirmation screens for space perception. We added a pair of gloves that suggests activities focused on the left-right orientation.*

- and the appropriate specialists - psychologists, special educators, parents, teachers and artists - provided us with priceless feedback during the whole design process. The possibility of checking constantly the compliance of our work with children's ideas and standards of the specialists allowed us to create a prototype of an educational application that was accepted by the children and parents ("it was fun", "I wish my child could use something like that"), approved by psychologists ("it doesn't disturb the childish world"), appreciated by special educators ("it develops children's skills in many different ways") and commented by artists ("the visual style is nice").

Even though we tried to co-operate with all the relevant persons as much as possible, it is not feasible to design a flawless application - although the iterative way of designing allow an approximation. In this last chapter of our thesis, we took all the comments and observations we got during the test sessions, and suggested modifications according to the children's and specialists' feedback.

We only regret we couldn't manage to provide the prototype with sound track at the end, because it would have enhanced the user experience in a new dimension. It could also reveal some important truths about sound perception and voice character matching during the test sessions. As all the specialists agreed that reading the instructions aloud with different voices is a must, providing the application with sound should be the first step in the next design phase.

Conclusion

Looking further into the contemporary problem of school attendance postponement, we suggested a prototype of an interactive educational application that aims to improve school readiness.

The application focuses on preschool children, offering various educational activities in a playful form. First we conducted a research that revealed what kind of exercises children should take on, and selected four categories that fit well the media we designed for: television and set-top box.

Then an appropriate visual stryle was chosen, inspired by children's fairy tale illustrations, based on the coloring books' clear style and nursery school teacher's recommendations. We also tried to learn as much as possible about children's color preferences, so that we can provide them with an interface pleasant to look. Considering the wide scope of different illustration styles oriented on children nowadays, we decided to focus mainly on the visual aspect of our application, as we felt there were many ambiguities to be cleared.

As we wanted to make sure children feel more like playing than studying while using our application, and the educational activities are well accepted by them, we designed four characters to guide them through the learning process: one for each category. The characters were designed to represent visual metaphors based on the activity they guide the children through.

Taking children's preferences concerning illustrations and the necessity of achieving a clean, understandable environment for the educational activities into account, we opted for vector graphics which is also easier to animate. The scenes constituting the interface, together will all the other components including guide characters were created in Adobe Illustrator.

To learn more about the working preferences of young children and to be able to establish an appropriate interaction design for them, we observed a group of preschoolers during a school-preparatory course. This experience, together with the findings described in papers treating various projects focused on children led us to the idea of using Microsoft Kinect, a controller-free device that allows users to interact with an application through body movements.

Our aim was to implement a prototype of such educational application, which we created in Adobe Flash, an ideal tool for making simple interactive movies. We designed the prototype to comply with all the requirements we were able to gather: it had to be meaningful in terms of the content, usable by children in terms of the interaction design and also acceptable in terms of visual design.

As we wished to follow the iterative design specifications, we evaluated our drafts during the whole design process. Thanks to the possibility of remote online testing, we were able to acquire valuable feedbacks from the target group which allowed us to transform the designs according to their preferences.

The finished prototype was tested both by children from the target group and specialists having experience in the field of working with the preschool children. Besides usability testing with end users, we thus employed expert reviews, methods belonging to inspection evaluations, to appraise the prototype.

The usability test allowed us to identify issues in interaction design and confirmed the suitability of employing Kinect as the control device, while expert reviews provided us with feedback on the activities content, visual metaphors and overall look of the application in general.

The reactions we observed during test sessions were mostly positive, and both content and form were judged acceptable by children, parents, psychologists, special educators and artists. As both the idea of such application and its prototype were accepted with an interest among specialists, we can conclude that an interactive educational application centered on preschool children is needed, and would thus be found useful. We tried to cover as many of the findings as possible in the current version of the prototype.

Due to the research nature of our work, its main contribution consists in the establishment of guidelines for children-centered design, which we verified during the test sessions.

Future work

Designing a prototype is only one step in the pro-

cess of the application design, so there is still a need to continue further with evaluations and redesigns. The most important issue to be resolved is the sound of the prototype, as each of the characters should address children with its own voice, providing so a complex experience. Another matter requiring further attention is the redesign of the time perception guide character.

The visual metaphors used in the character design should be revised in general, involving directly end users. As we created the guide characters relying solely on the infromation available in papers and provided by specialists, we feel that children should be more involved in the early design phase, influencing the final design much more. We feel that asking children about their own notions and perceptions concerning time, figures, space and memory can lead to a solid basis for more comprehensible visual metaphors.

Even though we proved the suitability of using television and Kinect for such application, we feel that there is also room for creating similar prototypes employing more direct interaction, which would run on touchscreen devices such as tablets or smartphones.

We would also suggest a tighter cooperation with the specialists from different fields involved, such as nursery school teachers or even musicologists. Establishing a close collaboration between science and humane fields represents a necessity in order to create beautiful, effective, usable and functional products.

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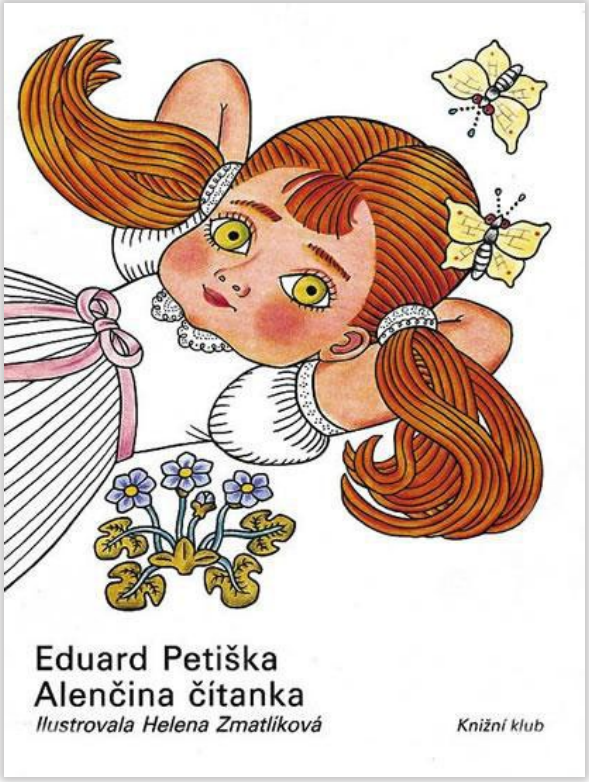
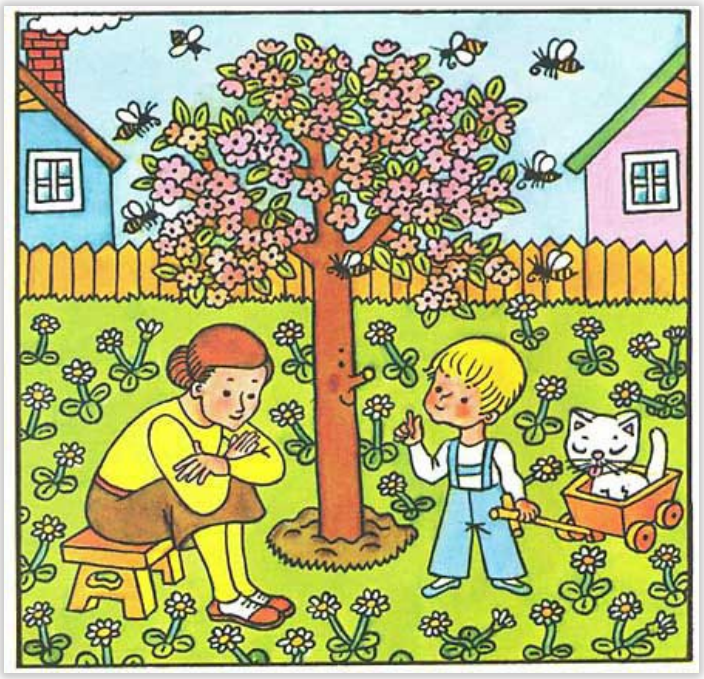
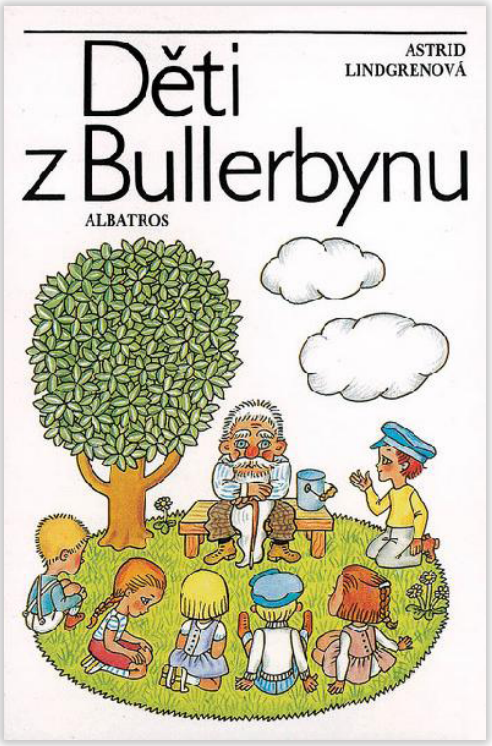
Appendix 1:
Visual design reference images

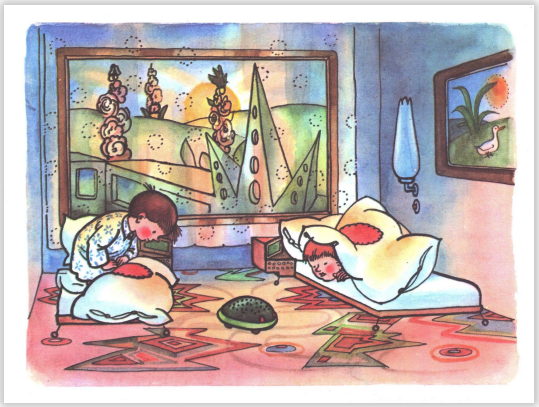






Helena Zmatlíková (1923 - 2005)

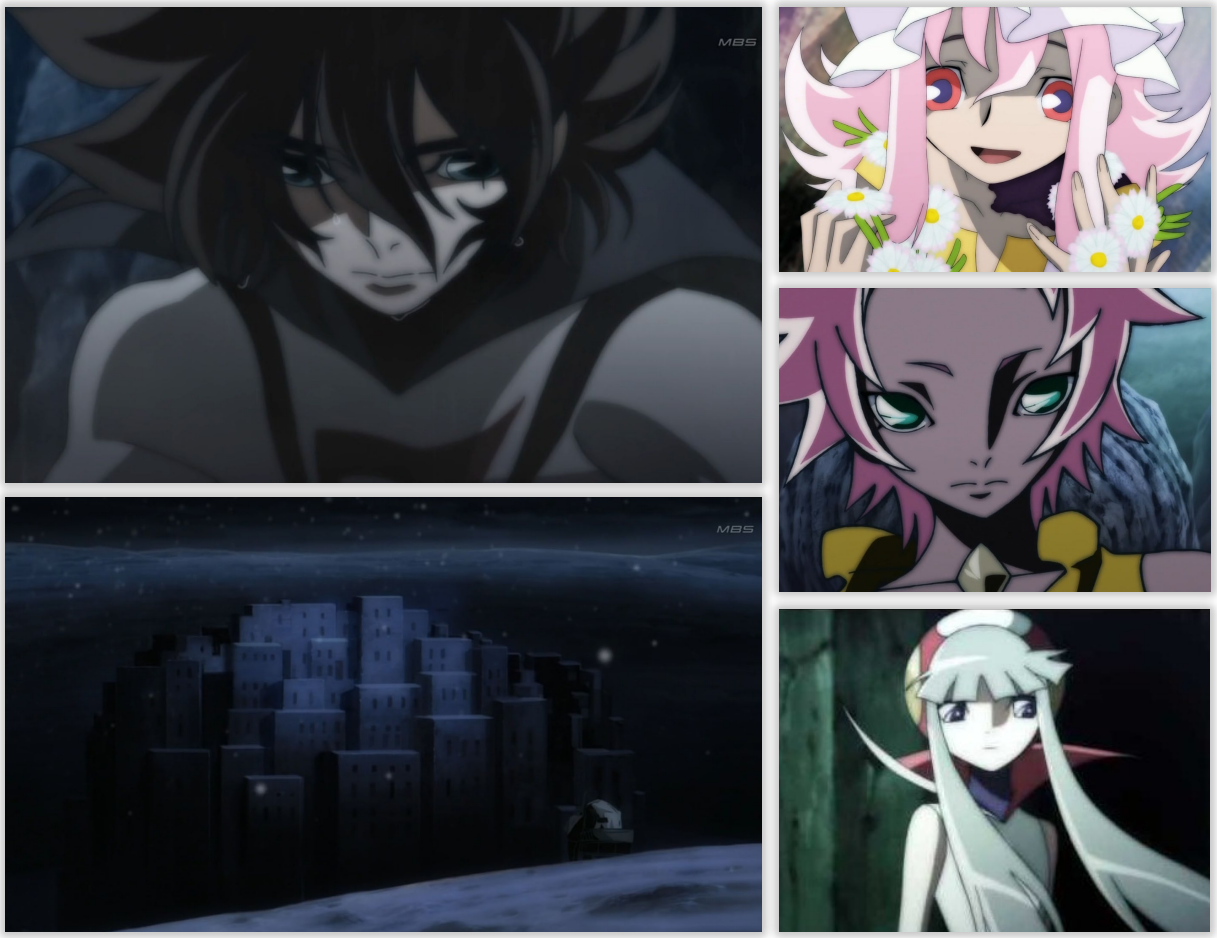
Helena Zmatlíková worked as an illustrator and created countless pictures for childrens' books. Apart from fairy tales and stories for young readers, she also accompanied spelling books and first-readings-books with her unforgettable illustrations. The pictures are simple, but always convey the necessary information in an original way.



Jaromír Zápal (1923 - 1984) was an illustrator and graphics art editor who specialized on children and youth literature. Besides illustrating Winnie the Pooh, Zápal also provided pictures for the Neználek trilogy by Nikolaj Nosov. The colors he used always suggest very warm and peaceful atmosphere.

Jiří Trnka (1912 - 1969) was a puppet maker, animator, film director and illustrator. Among his best known works are the pictures created for La Fontaine's Fables, Lewis Caroll's Alice in Wonderland and also Broučci, a book containing tales about fireflies by Jan Karafiát. In 1968, Tnka was awarded the Hans Christian Andersen Award for his illustrator career.

Zdeněk Miler (1921 - 2011) was an illustrator and animator who created a worldwide known character called Krtek. Besides books, Krtek's stories exist also in a form of TV bedtime stories and even short movies. It is also possible to buy stuffed animals based on him and his friends.

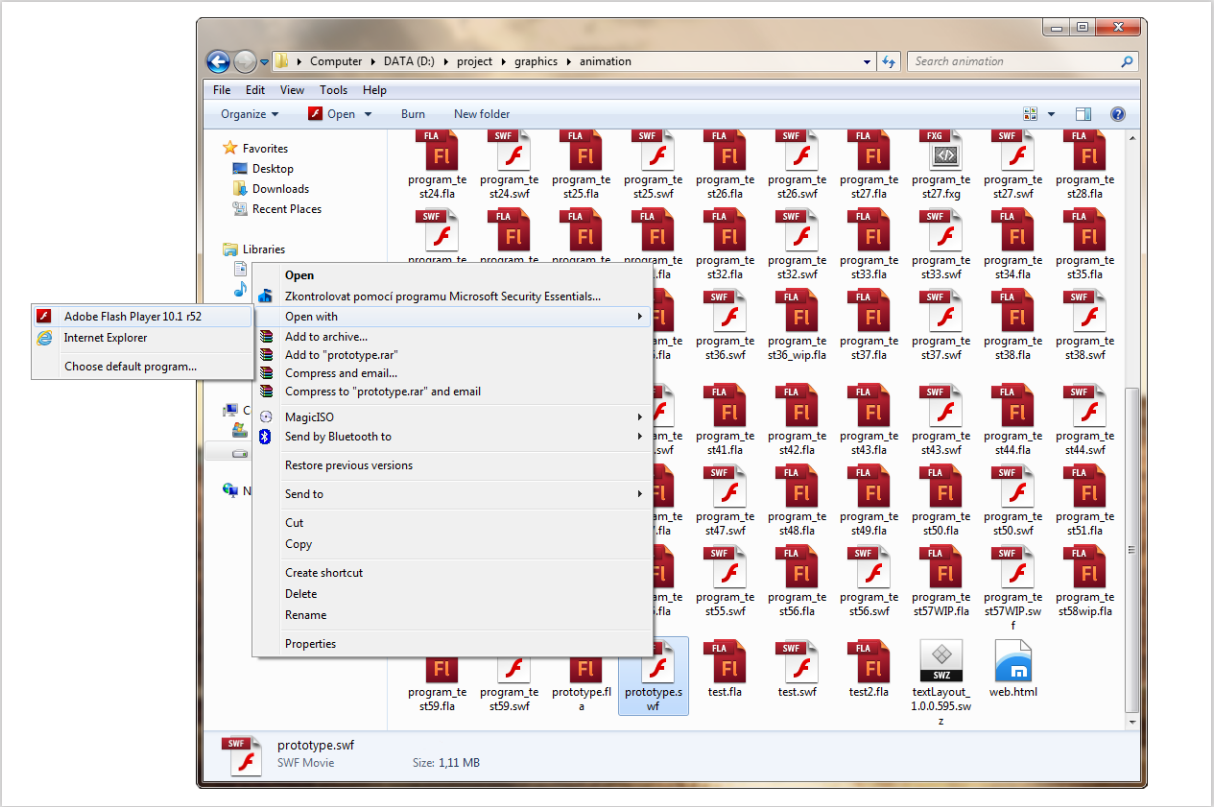


Some of the protagonists of Casshern Sins animated serie (produced by Madhouse, 2008): Casshern, Nico, Sophita, Luna and Ringo. The drawing style looks simple, but it depicts traits of each character with an admirable precision. Note the position, size and shape of the eyes: depending on these, it is possible to judge not only the age, but also the nature of the protagonists. We were inspired by the sublime graphic style as well as by the color choice - the palette artists used consisted mainly of light pastel tones applied on characters and contrasted by mostly dark tones of the settings. We think that the serie was composed this way to compensate for a sad story (bright characters seeking their way in a world filled with darkness).

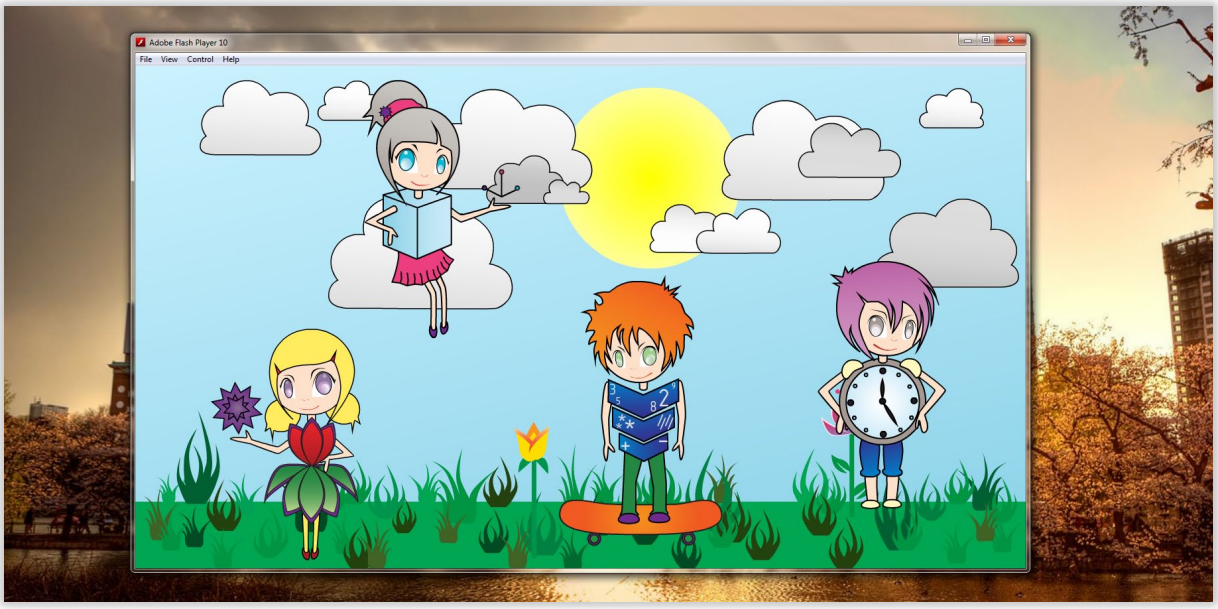
Pino, a character from Ergo Proxy animated serie (produced by Manglobe, 2006). She was actually a robot-child who got infected by a virus called Cogito and acquired her own will. The ability to experience human feelings influenced her so that she was able to make many different looks according to her mood. When we were looking for an inspiration for facial expressions of the guide characters, we tried to get inspired by Pino, because she looks friendly even if she is angry with someone or mad about something - and the guide characters should be like that too.

Appendix 2: Prototype guide

The prototype (which can be found on the enclosed CD) is written in ActionScript 3.0, and should thus be run in Adobe Flash Player 9 or higher. During the test sessions, we used Adobe Flash Player 10 (see the image below), which was installed automatically with the trial version of Adobe Flash CS5.



Opening the Shockwave Flash file in the newest version of Adobe Flash Player allows running the prototype without web browser (see the image below). The prototype has 1920 x 1080 resolution (in pixels), and is supposed to be run in full screen on full HD televisions or monitors.



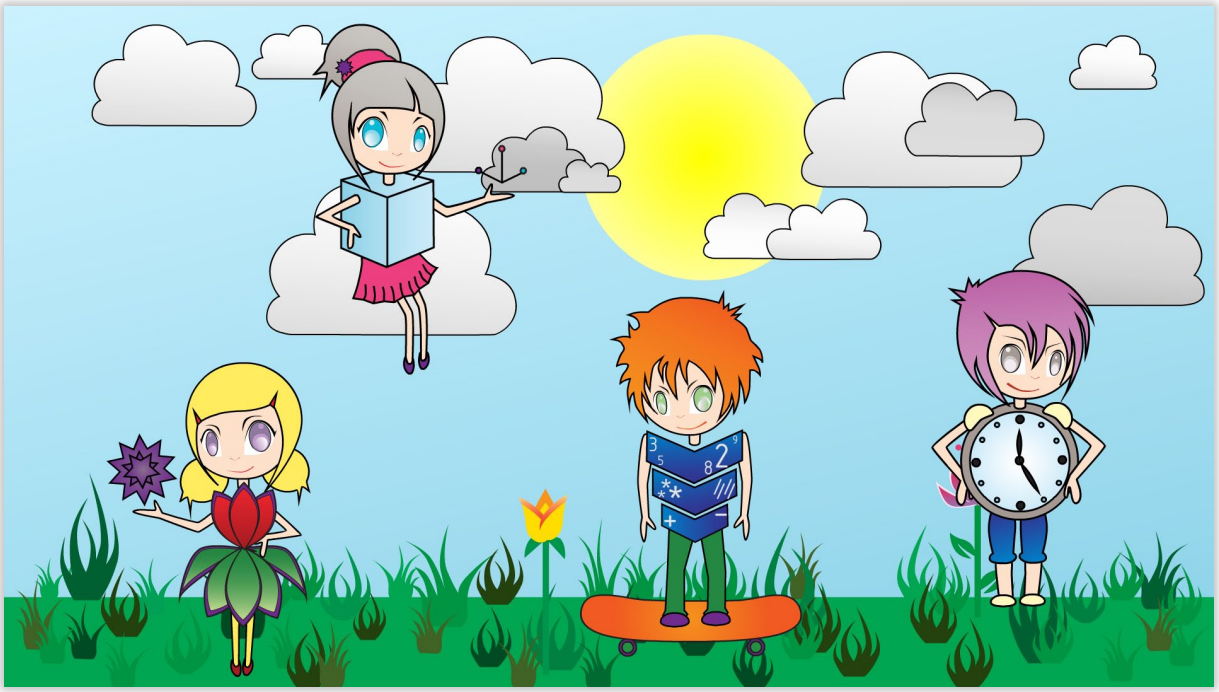
action	context	prototype controls	kinect gestures	feedback
start the application	main screen: meadow	click the sun	*	music playback, animation
learn more about each of the characters and activities they offer	main screen: meadow	place the cursor on the character	point at the character	character introduces himself / herself
select a character	main screen: meadow	click the character	continue pointing at the character	tone playback, change of screen
confirm the selection of the character	[character] confirmation screen	click the window with character	do nothing or continue pointing	tone playback, change of screen
cancel the selection of the character	[character] confirmation screen	click the element in the bottom left corner (pear or flower)	wave	scene changes: application returns to the main screen
proceed further in the story	[Počtík] windy landscape	click the bubble with the announcement	*	animation continues
pre-select the strawberry compote	[Počtík] front room	place the cursor on the bottle	point at the bottle	animation: character prepares to grasp the bottle
confirm the selection of strawberry compote	[Počtík] front room	click the bottle	continue pointing at the bottle	animation: character either nods or shakes his head; if the answer is correct, animation concludes the activity and the application returns to the main screen
pre-select a season	[Budík] gallery	place the cursor on the season's picture	point at the season's picture	animation: picture changes frame color and tree with the symbol grows bigger
select a season	[Budík] gallery	click the season's picture	continue pointing at the season's picture	tone playback + animation: picture grows bigger
return to the seasons' sub-menu	[Budík] gallery	click the season's picture	wave	change of screen: return to gallery
return to the main screen	[Budík] gallery	click the time character	wave	change of screen: return to the main screen
proceed further in the story	[Krychlička] children's room	click the bubble with the announcement	*	character gives the first task
find the candy	[Krychlička] children's room	place the cursor on the candy	point at the candy	candy grows bigger, providing a slight hint
select the candy	[Krychlička] children's room	click the candy	continue pointing at the candy	tone playback, character expresses praise

action	context	prototype controls	kinect gestures	feedback
proceed further in the activity	[Krychlička] children's room	click the bubble with praise	*	character gives the second task
find the book	[Krychlička] children's room	place the cursor on the book	point at the book	book grows bigger, providing a slight hint
select the book	[Krychlička] children's room	click the book	continue pointing at the book	tone playback, character expresses praise
proceed further in the activity	[Krychlička] children's room	click character's left hand	*	character gives the last task
find the ball	[Krychlička] children's room	place the cursor on the ball	point at the ball	ball grows bigger, providing a slight hint
select the ball	[Krychlička] children's room	click the ball	continue pointing at the ball	tone playback, character expresses praise
return to the main screen	[Krychlička] children's room	click the blue rectangle on the shelf	wave	change of screen: return to the main screen
proceed further in the story	[Pamětka] garden	click the bubble with the announcement	point at the character	tone playback, animation: change of screen, character gives another task
find the object that doesn't fit in row	[Pamětka] garden	place the cursor on the object	point at the object	animation: object grows bigger
select the object that doesn't fit in row	[Pamětka] garden	click the object	continue pointing at the object	tone playback, animation depending on the answer; if correct, character expresses praise and application returns to the main screen; if wrong, character shakes her head explaining the object does fit

Notes:
"*" means that the action will be taken automatically in case of Kinect-based application
"continue pointing at the screen" means pointing for about three seconds; this period is measured after a character stops speaking (if any).
"waving" should also take at least three seconds to be taken into consideration

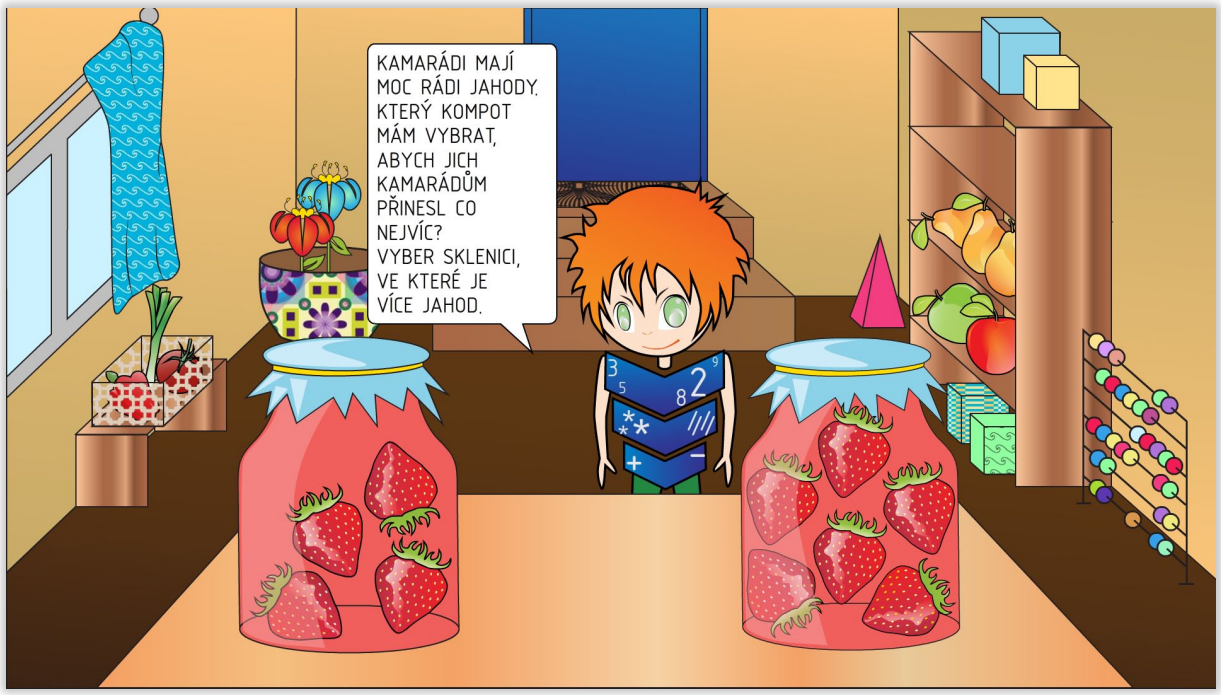
See the following pages for screenshots of the respective screens.

Main Screen of the Prototype



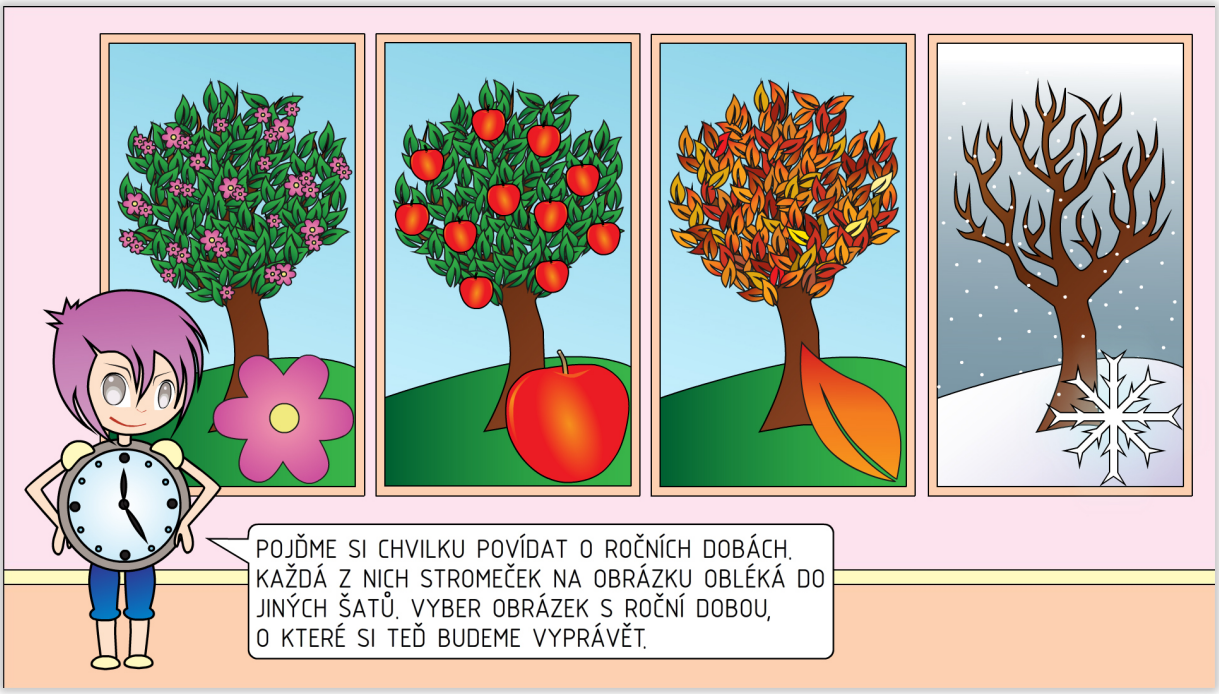
Meadow

Windy Landscape



Front Room

Time Perception Activity [Budík]



Gallery

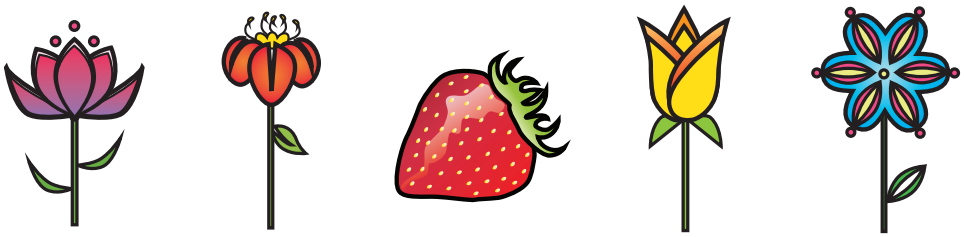
Space Perception and Orientation Activity [Krychlička]

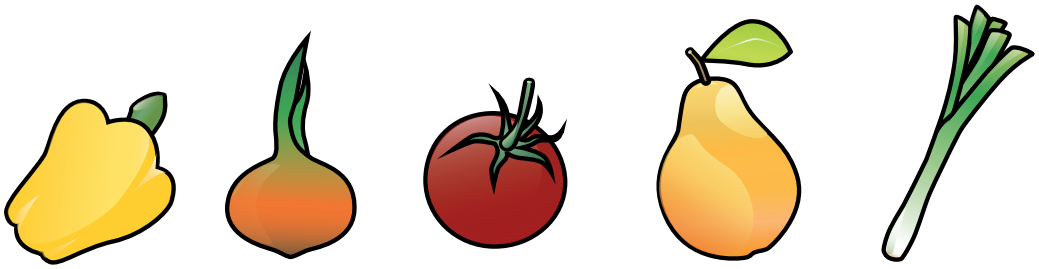
Children's Room


ZAHRÁDKA JE
V LÉTĚ PLNÁ
BAREV A TVARŮ.
ŘEKNI,
CO VŠECHNO NA
OBRÁZKU VIDÍŠ?

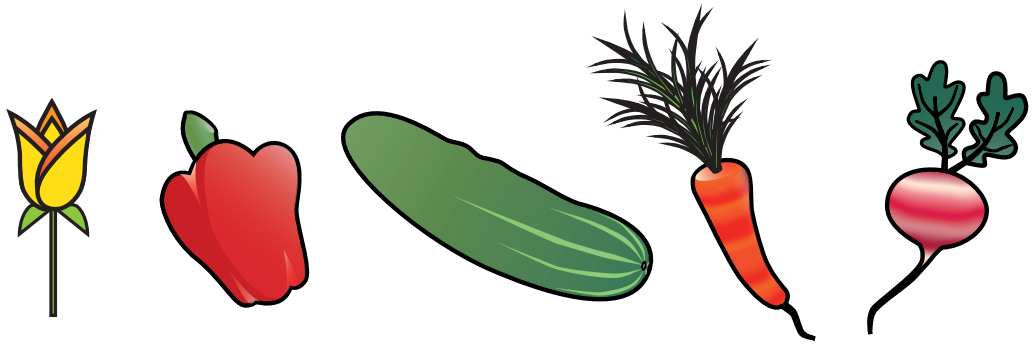
Garden

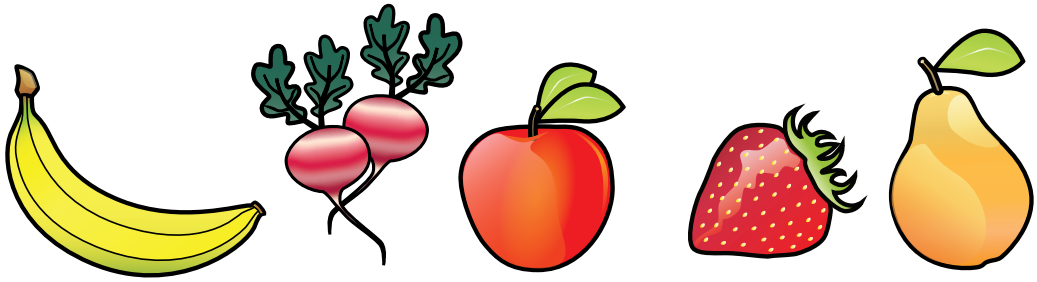
POZNÁŠ, CO DO ŘADY NEPATŘÍ?

1 

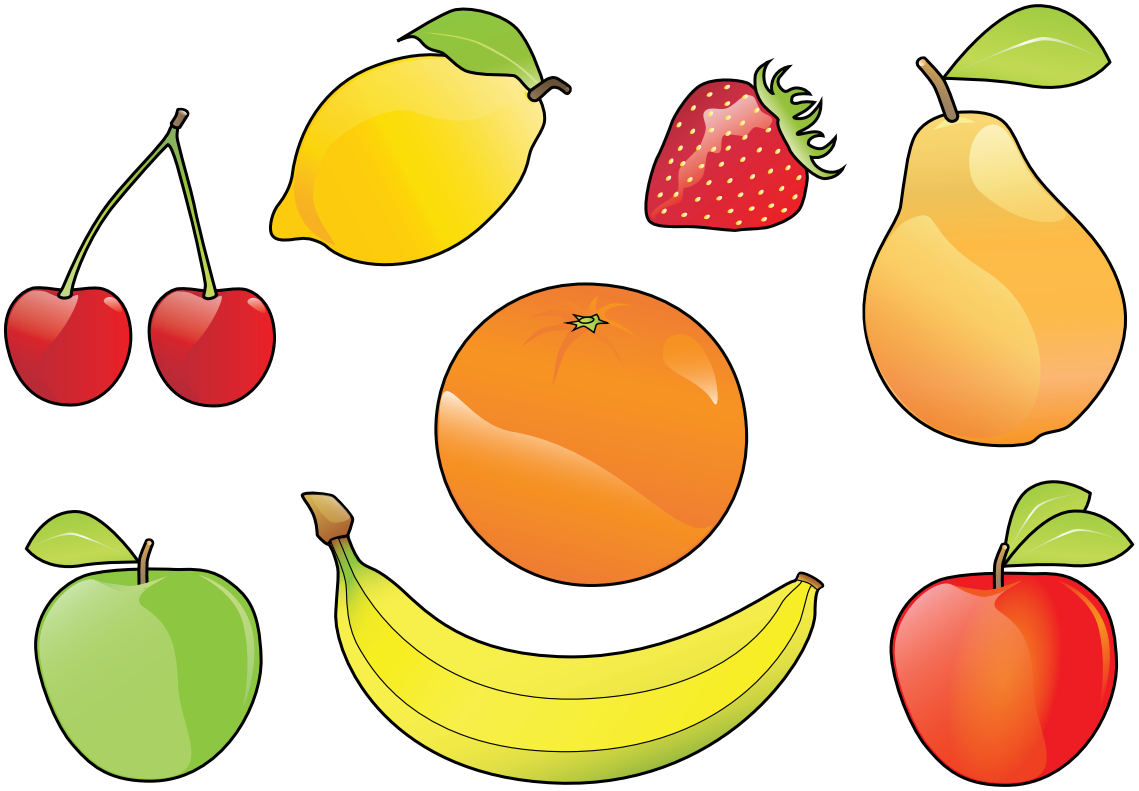
2 

3 

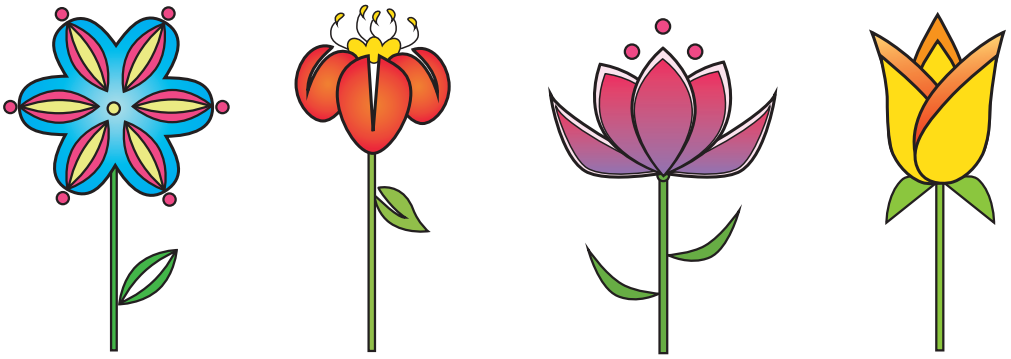
4 

5 

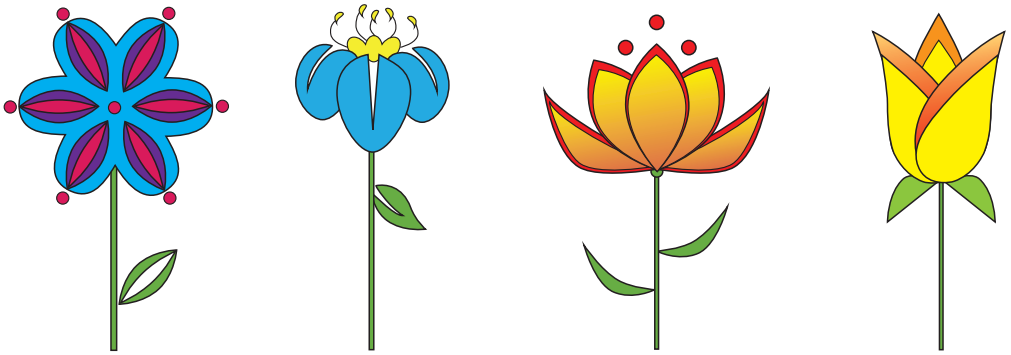
Appendix 3: Artworks



FLOWERS / 1



FLOWERS / 2



On pages 80-82, we placed some artworks we created during the design process, when we needed to clarify the graphics principles. For instance, on the flowers above, we confirmed that thicker black outline looks better than a thin one, and that gradients are nicer than plain solid colors. We also learnt how to combine bright and pastel colors.

The exercise on page 80 (select what doesn't fit in row) was consulted with a primary school teacher as we wanted to make sure it isn't too complicated - we were afraid children can use another clue than the objects nature. For instance, on the 4th row, is the misfitting object a flower (all the other objects are vegetables) or a cucumber (it differs in size and position)? We learnt that the exercise is fine, because it can reveal the fact that children use more than just one clue to solve it, which is a good thing.

Appendix 4: Contents of the enclosed CD

\ diploma_thesis

_artworks
__autumn.ai
__autumn_over.ai
__flowers.ai
__flowers.pdf
__flowers.psd
__front_room.ai
__fruits.ai
__fruits.pdf
__fruits.psd
__garden.ai
__characters_comparison.ai
__characters_comparison.pdf
__characters_comparison.psd
__characters_final.ai
__characters_final.pdf
__characters_final.psd
__childrens_room.ai
__math_char_exp_animation.ai
__moon.ai
__objects_row_exe.ai
__objects_row_exe.pdf
__objects_row_exe.psd
__spring.ai
__spring_over.ai
__summer.ai
__summer_over.ai
__sun.ai
__vegetables.ai
__vegetables.pdf
__vegetables.psd
__winter.ai
__winter_over.ai

_prototype
__prototype.fla (source)
__prototype.swf

_text
__diploma_thesis_tkadldag.indd (source)
__diploma_thesis_tkadldag.pdf