

# Concept of Interactive Coloring book

Tomáš Pastorek\*

Supervised by Petr Felkel†

Faculty of Electrical Engineering  
Czech Technical University in Prague  
Czech Republic

## Abstract

Coloring book programs are often simple and do not develop anything but mouse-move-and-click skills. The only task is to fill-in predefined regions by a selected color. This research exploits the possibilities offered by a computer to do more.

Based on discussions with a clinical psychologist, we designed an interactive coloring book concept to help preschool children in development of creative and logical thinking and basic computer operation skills. Children are offered a simple scene for coloring where individual objects can interact with their mouse input. The objects behave exactly as the children know from their every day life. The object reaction is physically simulated.

We present a pilot implementation of the interactive coloring book concept. The scene can be designed using elementary objects, images, sounds, and logic, allowing more complex entertainment. Scene description is stored in XML files, being simply editable and manageable.

We have successfully validated our concept by a user study involving 5 preschools and their parents. The good experiences lead to continue the coloring book development in cooperation with Faculty of Education, Charles University in Prague.

**Keywords:** Coloring book, Physics, Physical Simulations, Interactivity, Children, Games

## 1 Introduction

Coloring books are extremely popular among children, as most every child loves coloring. This simple and fun activity has also a positive effect on child development - it improves their graphomotor skills – their hand-eye coordination. These skills are later used for writing, drawing and other manual tasks.

Children of age 4–5 like tangible images, preferably with an already filled example, and basic colors. Undo function or an eraser can confuse them. Preschools (5–6 years) can handle more complex images, more color tones, and should be able to orient themselves in space

(up, down, left, right). They have developed an abstract thinking and do not need a colored example. Preschools can solve simple puzzles and quizzes.

Software implementations of coloring books as they are now available as web pages are only an imitation of paper coloring where the mouse clicks simulate surface coloring with a pencil. A complex movement with a pencil is replaced by simple clicking and the graphomotor learning effect of precise coloring is nearly lost.

The computerized colorings should bring something more, but the colorings available in the internet rarely bring anything really new in comparison with the paper ones. Based on discussion with a children psychologist, we proposed a concept of improved interactive coloring book including animation, physical simulation of moving objects, and programmable scene logic.

Introducing animation and physical response to the current coloring books brings an interesting combination that can attract children and certainly can develop more skills—from fantasy to logical thinking [1]. In addition, soundtrack gives an additional element to which children must respond. It is not a mere filling up of closed regions we know from nowadays coloring books, but the overall concept of a simply extendable multimedia software solution for the children entertainment.

## 2 Review of similar projects

Present coloring book applications are seldom downloadable as standalone programs. It is common now to present them in the form of web applications. The criteria used for evaluation of coloring book programs included the following ones:

**Interactivity** - should give more than just coloring by clicking.

**Controllability** – The user interface and usability for coloring must be in relation to the children age, for young kids as simple as possible without text. It should be understandable by the parents who help with the rules.

**Image for coloring** – should not contain small areas hard to target by the mouse cursor. Older children can have

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\*pastoto1@fel.cvut.cz

†felkepet@fel.cvut.cz

more complex images. The child should have a possibility to choose image for coloring from the set of images.

**The color palette** – should also respect the children age and their ability to designate the colors. Small children need basic colors and large color spots in the palette, older children can use pastel colors and small color spots.

**Graphic design** – should be eye-catching and attractive.

**Programming grade** - applied technology and amount of bugs in the application.

We have tested 15 coloring programs, five of them in greater detail (Interactive coloring book from Keith Haring Foundation [2], Coloring books at Apples4theteacher.com [3], National Association of Home Builders – coloring book [4], Fisher-price Click and Color [6], and Coloring book at Alik.cz [7]). Rating according to the criteria is in Figure 2 For additional details, see [16].

Interactive coloring book from Keith Haring Foundation [2] is an artistic group project. This group is organizes charitable campaigns focused on AIDS and children. Unfortunately, the main attention is fixed on the artistic aspect leaving out the usability and amusement for small children. Unfortunately, the control is too complex also for the school children.

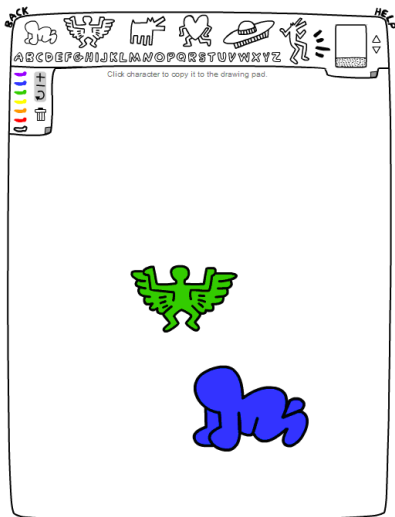


Figure 2: Interactive coloring book from Keith Haring Foundation

Coloring books at Apples4theteacher.com [3] is a very interesting project, outstanding in the number of images offered for coloring. A large number of colors in the palette could be a disadvantage for small children, as they cannot name all of the colors. On the other hand, the artworks are simple with large regions, which is good for small children.

Coloring book from National Association of Home Builders [3] is a complement service of NAHB oriented on construction, providing a small set of artwork for coloring. The way of coloring is distinct from others. It is a drawing by mouse with a trespassing control, avoiding getting across the region outline. The game offers a group of tools, including eraser and the brush stroke size. These features together with a large amount of colors fit to older children. The different way of coloring is more entertaining.



Figure 3: National Association of Home Builders coloring book

Fisher-price Click and Color [6] serves as part of web presentation of the company producing toys [5]. They offer online games for children of different age groups. Their colorings have very cute colors and real-looking palette and brush-shaped cursor. These features nicely adapt the user interface to the preschool children needs.

Coloring book at Alik.cz [7] is a Czech project of the Mafra company. It suffers from several problems, like wrong cursor shape (cross instead of pencil or brush) unsuitable for small children and an error in the code—it is impossible to recolor the region filled with a black color.

## 2.1 Conclusions from the review

*Preschool children* prefer large regions and images of real things, they know from everyday life. Such themes help them in selection of appropriate colors. Colored example images also serve well for inspiration. Palette should contain basic colors only, those the children can call by name. More complex tools such as the *rubber* or *undo* confuse the children and should be avoided.

*Primary school children* can cope with more complex images; physical simulations can contain simple mechanisms and logical quizzes. Palette can contain much more colors. Colored example images are not necessary. School children have enough fantasy and can improve their sense for art.

*The pilot program* should contain predefined palettes for different ages. The spots should be large to simplify the selection of colors. School children should get a color name

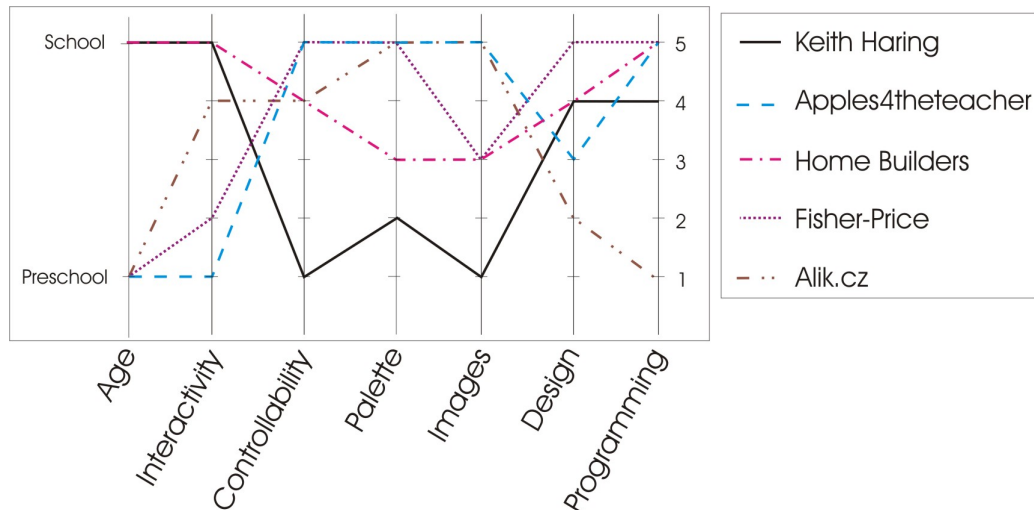


Figure 1: Rating of five coloring programs based on different criteria (1-the worst, 5-the best)

hint when the cursor stops on the color spot. The cursor must be large and recognizable to help selecting the colored regions. The environment should be cute and intuitive. The style of the image surrounding should be minimalistic, to avoid disturbances. A set of predefined scenes for different ages should be prepared.

### 3 Method

Based on the review of existing coloring applications we have designed a concept of interactive coloring book. The solution must allow a high level of configurability to match the needs for a larger range of children ages - from preschools to school children. The program should not limit itself only to coloring. It should contain tools for simple programming, applicable for a simple game development. Logical quizzes and different methods for coloring should be easy to implement. To fulfill these requirements, we have created a controller.

#### 3.1 Controller

Controller is a dynamic library (assembly) loaded together with the scene. It contains the control logic of the scene. Controller can create objects, set their specific attributes, play sounds, etc. Each object is addressed by its name, defined in XML in the scene definition file. Coloring program creates new instances of objects by reflection.

Communication between the scene and the objects is accomplished by event handling. For this purpose, the controller defines a fixed communication interface *IController*. Overview of the whole application architecture is in Figure 4.

The role of the controller can be demonstrated on the following an example situation: The scene contains a small disc, which should turn to red color after the mouse click.

Relevant implementation of the controller would look as follows. The handler of the *Insertion of the object into the scene event* is created. While creating the `disc` object, this event handler connects the *mouse click event* with it. Body of the *mouse click event* handler would contain the color-change command of the `disc`.

We can choose from the following events while defining the scene:

- Scene events
  - *SceneLoaded* - scene loading is finished
  - *ObjectLoaded* - object loading is finished
  - *ObjectAdded* - object has been added to the scene collection
  - *ObjectLeftScene* - object left the visible scene (useful for object recycling)
  - *ObjectCollided* - object collides with another object
- Object events - can be registered for each individual object
  - *MouseDown* - mouse click on the object
  - *MouseUp* - mouse release on the object
  - *MouseMove* - mouse move on the object
  - *BackgroundChanged* - object was assigned a new background color
- Palette event
  - *SelectedColor* - notification of the color selection

The system of scene control as described here is very important for the universality of the coloring application. The scene logic is not fixed, but it can be different for each scene.

### 3.2 Scene definition

Visual appearance of the scene is defined in XML document. XML was chosen as a simply human editable format as the scene editor was not part of this phase of the project. XPath technology [17] was selected for reading of XML files. It allows for fast access to particular elements in the document.

Every object in the scene has the properties defined in the XML file: Visual properties (such as width, height, position, rotation, color or image fill), physical properties (weight, vector of weight distribution), and other properties (data type including its namespace, object name for object identification in Controller).

The object definition contains only the name of data type (class name with namespace). This allows for introduction of new data types without a necessity to change the XML document scheme. Based on the data type name, new instance of object is created by reflection while reading the scene description. Our concept of interactive coloring book contains the following predefined objects:

- `ColoringBook.Objects.Rectangle`
- `ColoringBook.Objects.Ellipse`
- `ColoringBook.Objects.Polygon`
- `ColoringBook.Objects.Vehicle` – simple physical model of a truck
- `ColoringBook.Objects.Tire` – car wheel

## 4 Program architecture

The display layer (implemented by the Windows Presentation Foundation technology - WPF), receives the list of objects (interface `IObjectBase`) and the list of colors in the palette (`PaletteColor` class) via the `ObservableCollection`. It is a specialized collection able to announce the changes for the display. The changes are signaled to the display layer by means of `PropertyChanged` event.

Newton Dynamics physical engine is connected with the rest of the coloring application by the Proxy design pattern (classes `CWorld` – the physical world – and `CBody` – representing the object instance in the physical engine). Scene object for logic processing uses only the known interface `IController` – thanks to that, it is possible to create different scene logics by means of different implementation of this interface. See Figure 4.

## 5 Results

We present a pilot implementation of the interactive coloring book concept for Windows platform. This operating system has been selected based on the world statistics of operating system usage by the children target group.

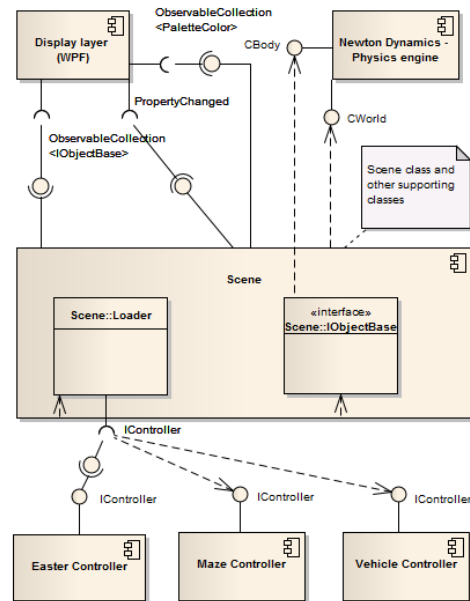


Figure 4: Component diagram depicting of interactive coloring book architecture. `IController` describes the logic of each scene

Development was done in C# language under the .NET Framework 3.0.

The Windows Presentation Foundation (WPF) was selected for rendering. It allows for direct rendering of vector graphics and for separation of application and presentation layers. By means of XML markup language XAML, we can define the application appearance independently of the code, the styles for elements dynamically, and create relations to database sources. This working style is similar to the working style of web designers. Another advantage is a simple portability to Silverlight technology.

As a physical engine, we have selected the Newton Dynamics [14] with a .NET wrapper [15]. This Physical engine is stable, fast, and well documented. With the .NET wrapper the engine is usable in the selected technologies (.NET, C#, ...) and provides a good set of sorts of joins. Integration of WPF with the Newton Physical Engine is very simple. The physical engine returns the positions and rotations of objects in matrix form. These matrices can be assigned as transformation matrices to the objects in WPF. We just have to use the same scales for both (see [13] for details).

### 5.1 Implemented scenes

To demonstrate the abilities of our interactive coloring book concept we created four example scenes. An Easter Eggs scene, Path Coloring, Truck, and a Music scene.

**Easter eggs scene** The task of this scene is to fill in the eggs ovals with an appropriate color. The steps the eggs lay on can be colored anyhow. After filling in,



the eggs start rolling and falling down to the bunny. The moment all the eggs fall down to the bunny the fanfare is played and the game is over. The eggs scene with newly assigned colors appears and a new game starts. The video of this scene can be seen on [19], the scene preview is in Figure 5.

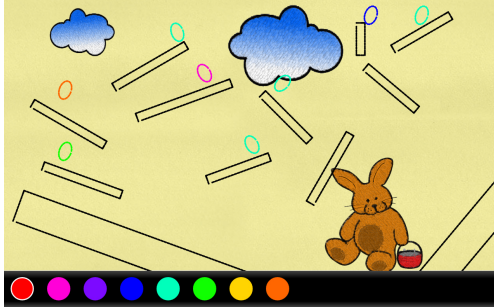


Figure 5: Easter eggs scene

**Path Coloring** In this scene, the user must create the path for the marble to get it into the house. The path is built by coloring the rectangular steps. The marble can roll on the filled steps only. Non-filled steps does not support the ball and it falls down. The correct filling order is: all the steps first, then the marble to release it onto the path. Fall out of the scene and reaching the house play a sound and the game starts again. The video of this scene can be seen on [20], the scene preview is in Figure 6.

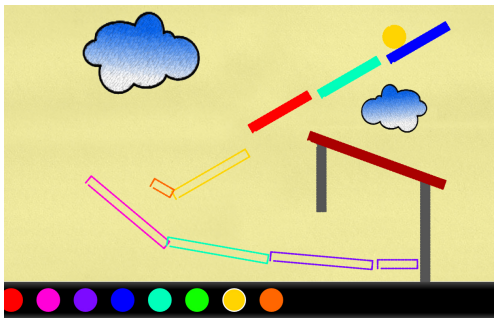


Figure 6: Path scene

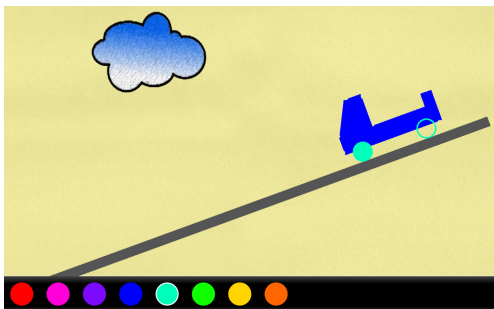


Figure 7: Truck scene

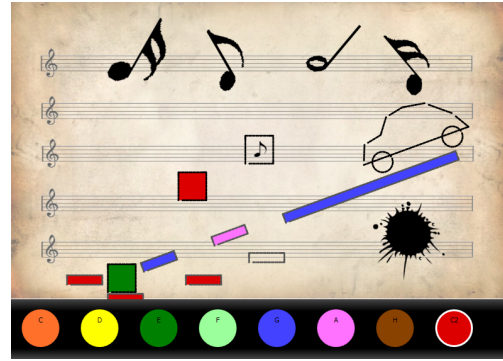


Figure 8: Music scene

**Truck Scene** This simple scene shows how to create and control vehicles. After coloring the truck body and wheels, the motor turns on and the truck drives down the ramp. When it reaches the scene border, colors are reset and game starts again. The video of this scene can be seen on [21], the scene preview is in Figure 7.

**Music scene** The task is again to create a path for a vehicle. After coloring the path pieces and after filling the holes by fallen colored rectangles, the car can be filled in and it starts moving down the ramp. Each ramp piece sounds different tone, given by the applied color. If any noncolored path piece remains, the car cannot start and honks. The video of this scene can be seen on [22], the scene preview is in Figure 8.

## 5.2 Mini usability study

Usability of the product can be defined as the grade people can use the product to fulfill given tasks [18]. We have performed a very limited low cost low effort mini usability study. By means of this mini usability study we wanted to find out, how the users liked the user interface, how they reacted on different scenes and what experience the scenes left behind in their minds.

Interactive coloring book program was tested by five users: two girls, 5 and 7 years old, with previous experience with a computer; two boys, 4 and 7 years old, with no and very little experience with computer; one woman, 39 years old, with computer skills. The user study was performed on the first three scenes.

We have used a full screen mode in the user study, enlarging the regions for coloring and avoiding erroneous clicking outside the coloring book program. The evaluation included: a) Work without any help, where the user should find out, what is the goal and how to reach it, b) work after possible oral help, c) selection of appropriate colors, d) coloring itself, and e) final oral evaluation.

Main problems arising from the user study included:

- At the beginning, it is not very clear what should be

done. Sometimes, oral help is necessary for understanding the goal, especially for the younger children.

- The pencil (cursor) does not change its color. Children have problems to recognize which color is selected.
- By color selection, they did not recognize, that the point of the pencil (cursor) is the selection tool.
- Marking of the selected color in the palette by a white border is not sufficient, as the children took time to recognize, that the selected color is marked by a white circle.
- Some color tones are very similar and therefore hard to distinguish.

The children liked the scene with a truck the most because its coloring is simple and the finished task is rewarded by an engine start followed by the truck movement.

## 6 Discussion

The potential of the interactive coloring book concept can be used for development of simple entertaining games for healthy children. It can be employed for learning basic computer skills through play, for logical thinking improvement, and for phantasy development.

In cooperation with experts on special education, we can create puzzles focused on children with light disability. Nowadays, we work on extension of interactive coloring book concept for visually impaired children in joint project with Faculty of Education. There is lack of such oriented software.

Simultaneously, we do not limit us to coloring books. It is possible to create simple games exploiting the physical engine.

It proved in practice, that the selected technologies were chosen well and they exactly matched our assumptions. Only if we decide to port the Interactive coloring book to web platform Silverlight, we would have to change the physical engine (e.g., to Farseer Physics [23]).

As the thorough reviewer correctly mentioned, “there is a real danger that children will lose the ability to hand write if they are constantly just using a mouse and keyboard”. A different method for coloring, e.g. such as stylus or computer with a touch screen like TabletPC should be designed and tested. Having no such specialized hardware we have not addressed this in our study and implementation, leaving it for possible future work.

Usability tests did not reveal any serious problems related to the concept or implementation of this project. All issues that appear can be solved by scene file modification or by small changes in the program. Usability tests verified that our introductory presumptions were correct. Children accepted physical simulations well knowing such behavior

from everyday experience in the real world. Simple and intuitive user interface is also important, mainly for the first steps with the new program. Even though the mini user study showed minor imperfections, the children accepted the interactive coloring book very well.

## 7 Conclusions

We have presented a concept of interactive coloring book and a pilot application based on this concept. They were designed in cooperation with a clinical psychologist with the main idea in mind – how to use computers in children entertainment better. The classical paper-and-pencil coloring scheme cultivating imagination and sense for colors was enriched by the physics simulations helping the children to understand the interactions among objects in the real life.

The capabilities of the interactive coloring book were demonstrated on four scenes. The Easter egg scene prepared for the smallest children was a simple coloring by appropriate color. Next scene contained a ball and the path split into parts. The parts had to be colored before releasing the ball to get it to the end post. The last two scenes contained a ramp and a vehicle. The truck in the former scene started moving down the ramp after filling up the ramp and the truck body. The latter scene with a car was enriched by playing tones according to the color selected for coloring.

In principle, it is not complicated to create a new scene with any functionality, because the scene logic is stored in an XML file and not fixed in the program. The pilot application tested the concept of interactive coloring book and proved its popularity among the children.

## 8 Future work

After the validation of interactive coloring book concept, we concentrate on creation of the development environment for scene creation and scripting. Such a tool will serve for fast creation of simple games with physics simulation. Simultaneously, in cooperation with the special education department at the Faculty of Education, Charles University in Prague, we work on the set of games and research tools for visually impaired children.

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