

Story Table
A multitouch table application for children

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BSc Report

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1 Summary of the Thesis

Creativity is an valuable skill that enriches and alleviates our life. Many people see creativity more as a talent than as a skill, but research has shown that it can be trained and enhanced. In this project we develop an interaction technology based application to enhance children's creativity. We describe the exploration of the concept resulting in the Story Table set-up on a multitouch table, supporting story telling. This concept aims to train children's divergent thinking and thus their creativity through enforcing the need to make unusual combinations within the story telling process. In the further course a prototype application of this concept was designed and realized having the special children's needs and the aim of the application in mind. Subsequent a functional testing and user evaluation was performed to examine the effectivity of the application in respect to the research topic and its previous defined requirements. Concluded is the thesis by a discussion of the work and its results, and a perspective on potential future work on the Story Table concept and in the field of creativity enhancement.

2 Statement of the Research Question

2.1 Given Research Question

The Research Question for this graduation project was given by Dr. Panos Markopoulos, Professor at the University of Technology Eindhoven as part of the User Centered Engineering Group within the Industrial Design Department. Dr. Markopoulos has been strongly involved with the field of Interaction Design for Children and is also co-organizer of this years Interaction Design and Children Conference (IDC 2013)¹ in New York. The research assignment was formulated as follows:

”... explore how interactive technologies could enhance children’s creativity.”

A reference given for orientation is a workshop² held in June on the IDC 2013 conference [Decortis et al., 2013]. An additional advise was to define the target group for this research and the prototype already in the beginning due to the specific and highly various needs of children in different age stages.

Following this advice we defined our target group as:

Children in a pre-school age on the edge to start primary school (4-6 years old).

2.2 Relevance of the Topic

Creativity is important for the development of children’s core abilities. How big it’s role is in traditional fields like science and math is topic of research nowadays [Decortis et al., 2013, p. 3]. Although creativity seems to have an influence on the learning process, current educational curricular tend not to foster student’s creativity and ability to improvise in and solve unexpected situations [Decortis et al., 2013, p. 3]. New interactive technologies and devices have their entry in the classroom on a bigger scale these days. These ”technologies can contribute to the development of peoples creative thinkers”, if they are properly design and used [Decortis et al., 2013, p. 3]. For this reason an exploration and investigation on the effect of different interaction technologies on children and their creativity is relevant for future development in this field.

¹<http://idc2013.org>

²<http://itecc.paragraphe.info>

3 Ideation and Exploration

3.1 An Idea About Creativity

3.1.1 Creativity: A Definition?

We start with a small introduction to the domain of creativity and creativity research:

After screening research in this area it becomes clear that there are various definitions of creativity. In fact those definitions show significant variations. This is most likely caused by the often conflicting research and miscommunication in the field. People, also experts, have a different perception of creativity [Makel and Plucker, 2008, p. 248].

One of the possible definitions, as an example, is the following:

“Creativity is the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context.” [Makel and Plucker, 2008, p. 90]

Most people think creativity is only needed by persons that are into the fine arts. But that is only the “big C”. Actually people use the “little c” on an every day basis to master their lives and challenges in various domains [Makel and Plucker, 2008, p. 251].

The most relevant to creativity is the ability to generate numerous responses, the so called divergent thinking [Makel and Plucker, 2008, p. 249]. This skill is worthwhile to train and develop due to its high value in the economic and technological industry. It is a fundamental core ability to creative problem solving. Enhancing creativity can thus mean being successful in life.

3.1.2 A Starting Point

As shortly discussed in the previous section creativity has a high complexity and variety. On this reason developing a concept that enhances or fosters creativity can be a challenge. A potential starting point is a brain storm on children’s activities that are widely known and esteemed to be creative as illustrated by a mind map in figure 1. This mind map shows typical areas and fields where creativity is applied like painting, composing or playing music, role playing or story telling (pink labeled) as well as its initial triggers like someone’s imagination or curiosity (yellow labeled). Accordingly, there is a number of ingredients for creativity. There is no recipe or algorithm that commonly guarantees any or the most creative outcome yet. Creativity *can* start just within someone’s head. However those internal processes are in most cases continued and enhanced through the realisation process. While starting without any imagination within the head and a blank canvas is also equally common. Consequently those activities are also triggers for the creative mind and reversed, ending up in an theoretical endless cycle of stimulation [Resnick et al., 2005, p. 11]. Which makes those activities certainly so attractive to the human mind. Hereby we realize that there is a wide range and variety of activities and triggers for creativity.

During the development of the mind map in figure 1 one common aspect of the different processes became obvious. Regardless whether listening to a piece of music, gazing at a painting, observing a beautiful building or watching a play in a theatre it is most likely that the

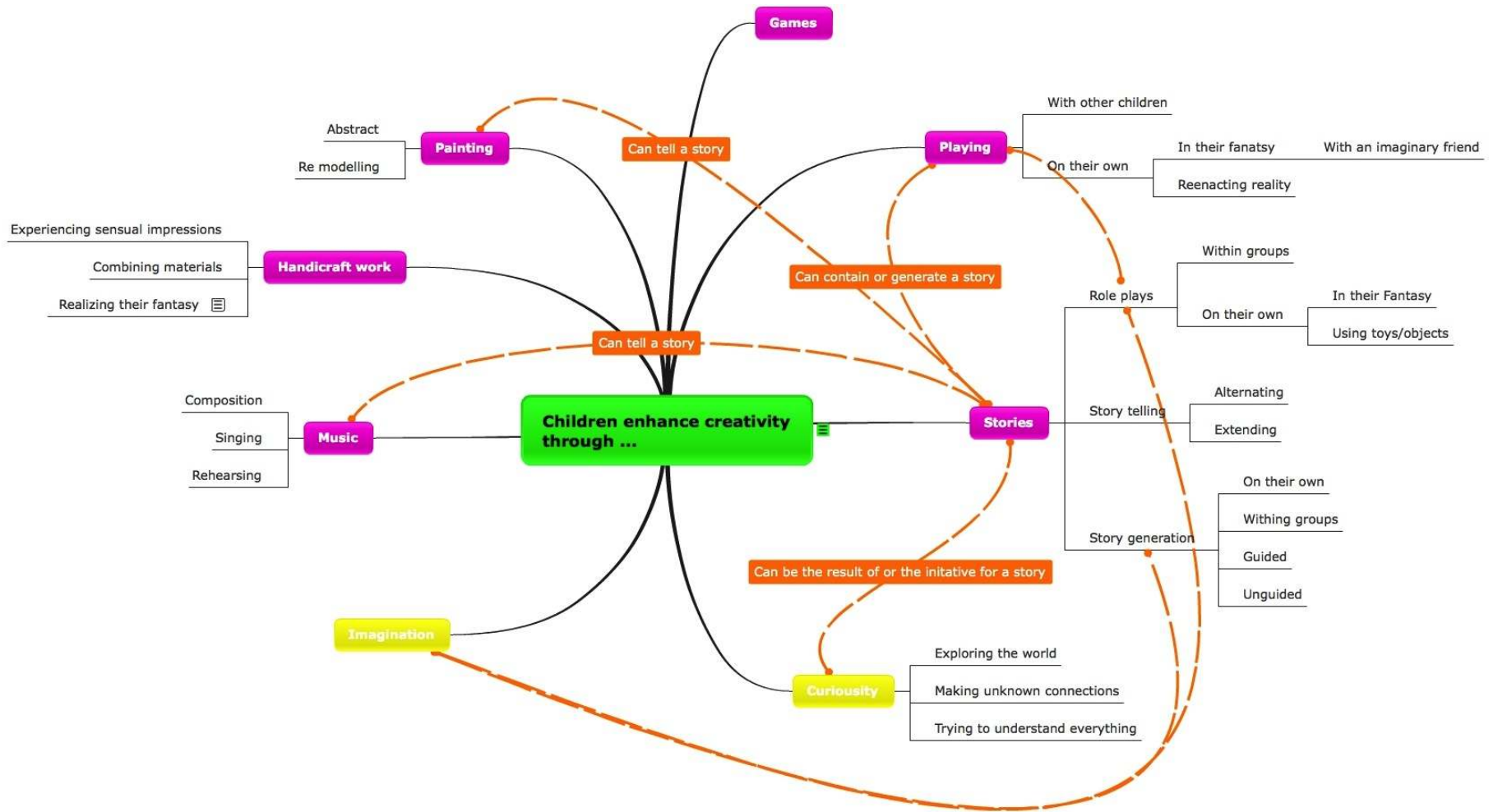


Figure 1: Mindmap on triggers and realisation processes for creativity.

authors had a story in mind during its creation. Stories are very *essential* to humanity. They are archive for our history, transmitter for feelings and empathy and metaphors for everyday life. A place where free imagination can come true. They are commonly known within society and so easy accessible to a broad audience. That makes stories a useful tool for many purposes and should be also considered for the enhancement of children's creativity [Hall, 2012, p. 96].

Exploring how the concept of story telling can function as tool to stimulate creativity, will be one core element within this project.

3.1.3 Refinement of the Topic and Research Question

Starting point for the following discussion is the claim that collaborative and free story generation can be an effective way to enhance children's creativity. It is a common thing to do in kindergarten and primary school, where a group of children generates a story together, in most cases initiated and directed by an adult person. Within this stories the children can express their imagination. They can construct stories that are not possible or not easily realisable in real life. Even the interaction within the group can encourage and inspire the children in their creativity.

Adding interaction technology to this concept could lead to some enhancements. The amount of needed supervision could be limited and lead to a more uninfluenced outcome generated by the children. Furthermore the share of participation of each child could be increased due to the smaller group size in comparison to the conventional activity and the stimulation of more introverted children through the interactive application.

These claims lead to the following refined research question for this project:

Is supplementary interaction technology improving and/or expanding an already existing concept for creativity enhancement, in this case collaborative story generation?

An additional definition of the detailed aim of the intended application enables to direct the design process in the desired direction more easily:

The planned application should fit within the category of games. But it should be different than conventional computer games. In those the story line or main task is executed within the digital environment. Within our application the main task should happen in the physical world. The intended application should function more as a tool providing input for story telling through random triggers and offer a opportunity to document the generated story instantly in a rich way [Resnick et al., 2005, p. 4]. Furthermore the application should be a space to explore, expand and train divergent thinking abilities through creating very unusual combinations [Resnick et al., 2005, p. 3]. In opposite to other strategies for creativity enhancement the usefulness and common correctness of the outcome is not important since the application should open up children's imagination and engage to extroverted idea exchange.

3.2 An Exploration on Creative Concepts

In the following a list of examples containing interaction technologies and game concepts aimed to enhance children's creativity. This list is obviously not complete but is meant as an explorative and inspiring set of examples.

1. **Build Your Wild Self**³ This web application requires the child to first form an avatar with his real appearance as reference. After finishing this initial task the application enables the children to enhance his body by exchanging his virtual avatar's body parts with those from animals.

The interesting factor here is that children can express and capture their imaginary self with abilities and attributes that they could never achieve in real life.

2. **Ravensburger Mix-Max**⁴ is a board game in which people with different sex, origin and professions are divided and separated into four equal parts. Within the game the children are asked to mix up the parts of different people and assemble new creations.

Mixing up of different not related and dispatching objects can be a great and fun possibility to enhance creativity and widen imagination and is therefore a worthwhile concept.

3. **Rory's Story Cubes**⁵ (see figure 2) Playing with this cubes means throwing the dices each having cartoon-like symbols on each face and tell a story with the faces heading up, not matter what comes. There are several strategies to play. There is the more rational approach where all dices are thrown at once and then a story can be build up in advance before telling it. The other approach would mean to throw one dice after each other building up the story more dynamically what requires a more creative and flexible mind. Another important rule of the game is that there is no rule what is right or wrong. Symbols can be interpreted and included in the story in any possible way.

Whatever strategy is chosen, this game is an excellent way to exercise combining and connecting parts from potential different domains. This can be an opportunity to train the divergent thinking and be a first approach for creative problem solving.

4. **Noteput**⁶ is an interactive music table with a tangible user interface (TUI) consisting out of music notes that can be placed on a projected staff. In this way the user (children) can explore the world of music by dynamical interaction and direct feedback. They can even learn the musical notation, exercise to recognize and using it and finally compose themselves.

The playful interaction, direct feedback and the format of an table makes it an interesting and attractive tool to be used by a single person as well as in groups.

5. **Draw A Stickman**⁷ Is a complete new way to experience the storyline of a game. The player is involved in developing the story through be demanded to draw certain objects and solutions to an occurring problem himself. The game gets immediately personalized through the player's contribution.

Building on this concept a development of a game where the user can draw any content

³<http://www.buildyourwildself.com>

⁴<http://www.youtube.com/watch?v=vRxQOom-OVI>

⁵<http://www.storycubes.com>

⁶<http://www.jonasheuer.de/index.php/noteput/>

⁷<http://www.drawastickman.com>

he wants and the game would react dynamically would be interesting. This is obviously an aim that is not as easy achievable. But a segmental implementation is maybe realisable.



Figure 2: Rory's Story Cubes - tell a story with 9 random symbols

3.3 Filling the Concept Pool

Taking previous concepts into account and as inspiration, we came up with a great amount of various characteristics and functionalities. We first collected all those within a big pool to have a wide variety to choose from as you can see in the mind map on page 9. The main functionality of the application should be the story generation process. Logically most functionalities of the application will be connected to or included in this process. Following a list of the possible features extracted from the mind map (figure 3):

1. **Random triggers** Random elements influencing the story generation process will be the key element of the application to increase the level of needed creativity and flex the limits of children's imagination.
 - (a) **Random story symbols** Receiving random symbols showing things from different domains like every day life, fairytales, work life, nature, etc. to construct a story around them and connect them using creativity. These symbols are movable on the screen to enable interaction between them and also arranging them in a specific order. As with Rory's Story Cubes (see point 3 p.6) they could be two different or only one of those two modes to play:
 - **Get all symbols at ones**, supporting a more hard liner approach that enables the possibility to plan the story in advance before telling it.
 - **Get symbol after symbol**, extending the story dynamically which requires more flexibility giving the soft liner skills a chance to be used and trained.
 - (b) **Random events** added in random intervals and amounts that create a challenge (like: a dragon that attacks, a thunderstorm that occurs, etc.) could increase the level of needed creativity and its enhancement. A first move into the direction of training immediate and creative problem solving.

- (c) **Random scenes** Putting every story in a randomly chosen context. Fitting the story consisting out of the random story symbols mentioned before (1a) in a maybe not matching scenery will additionally stimulate the creative mind.
2. **Symbol skills** that add another dimension of variation to the story. Those skills like flying, throwing fire or water, being incredible big, bouncing around, etc. can get attached to the symbols described in 1a to create new unusual combinations. Accessorily these skills could be animated to add more interactivity and make them more appealing to the children (see point 1 in the next list for more details).
 3. **Story characters** Characters are the usual thing to construct a story around. They are the element of a narrative mankind typically identifies which enables empathy with the characters and the story and improves the experience. Questionable is whether a deep personal involvement of the children is achievable and desirable.
 - (a) **Popular Characters from Books** Integrating popular characters from known publications for children could increase the attractiveness of the application for the children to use it. They could retell already existing stories of the characters, expand those or tell totally new ones.
 - (b) **Own Created Characters** Own created characters do also have they advantages. Creating them will also require some creativity and telling stories with them could be more attractive to children since they are made by their own.
 - **Super Self** Taking this feature further it could be an opportunity for the children to built up their super self (inspired by Build Your Wild Self, see point 1 p.6). Having skills and experiencing adventures they always dreamed of.
 4. **Additional drawing** Allowing the children to draw during the story telling could influence the generation process, potentially enriching the story. In any case those drawings would represent one form of story documentation. Other options to document them will be discussed in the further course (see point 2 in the next list on p.10).

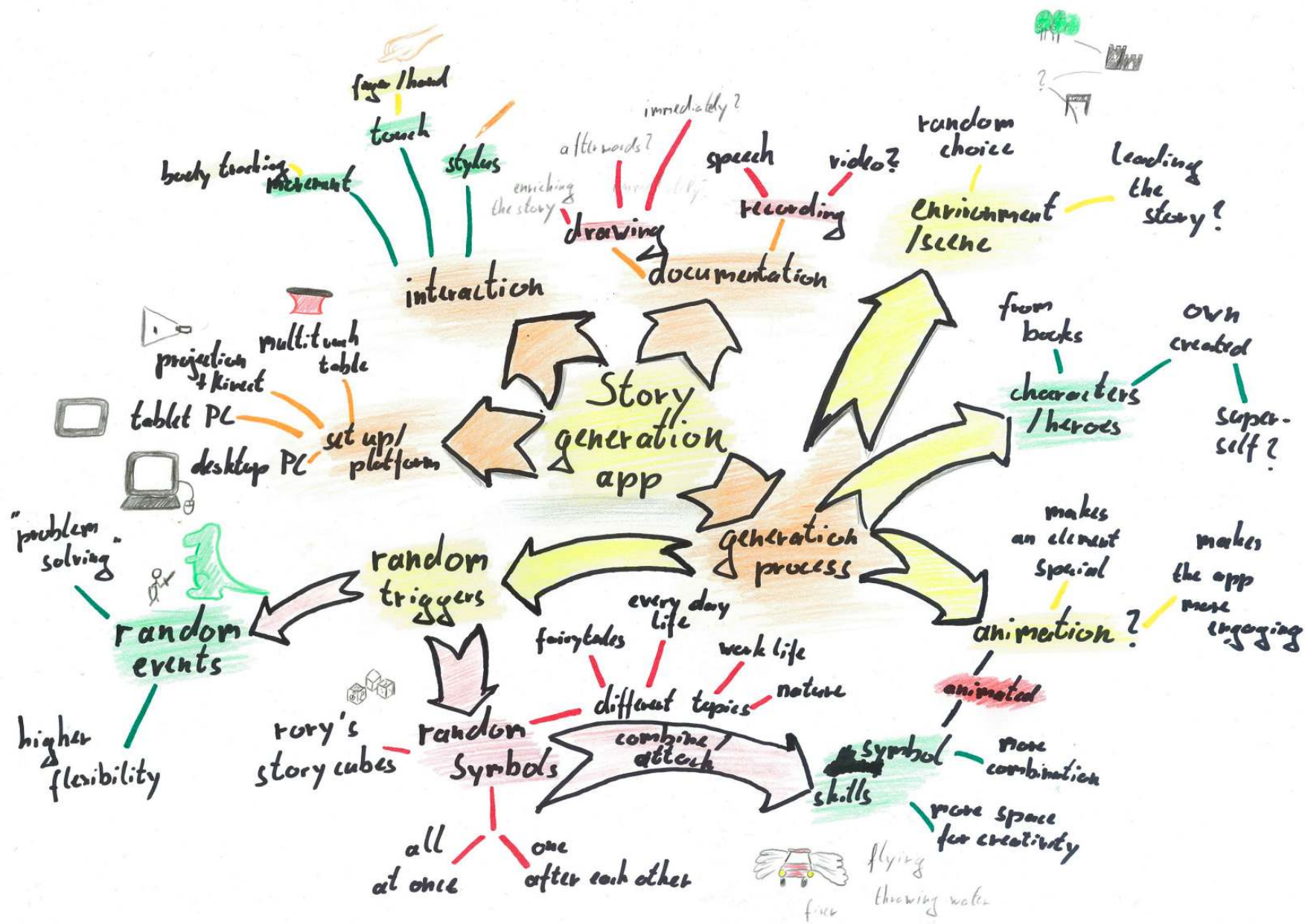


Figure 3: The pool of possible specifications and functionalities of the application.

Next to the story generation functionality there are some more specifications and functionalities that are important for the whole concept.

1. **Animations** As already mentioned animations are increasing the attractiveness of a digital application. If something is changing or moving the attention will be directed more on the application, maybe more on that specific element. Animating a graphical element can make it more special and appreciated by the user. This is one advantage digital games have over traditional board/dice games.
2. **Story Documentation** Documenting and archiving is also easier in the digital domain. There would be several options to document a story within the application:
 - (a) **Drawing** during (or after) the story generation would be one way to document the elements of the story besides just saving the set and the position of the story symbols on the screen. Drawing on a separate sheet of paper is for sure also possible during a game with the story cubes. But there the involvement of the symbols with the drawing and the archiving of it later is more difficult.
 - (b) **Voice Recording** would take the documentation on a more detailed level. Besides what is happening on the table the actual story told by the children would be documented. In this way it would be come available and suitable to be played back on a later point in time.
 - (c) **Screen Recording** would additionally also capture the dynamic development of the story and also the potential interaction of the different story symbols.
3. **Platform** A number of different technical platforms and set-ups are possible for the application.
 - (a) **Desktop PC**
 - **Advantage:** Commonly known, distributed and available.
 - **Disadvantage:** Not very suitable for group collaboration. Non intuitive interaction through mouse or keyboard, are not that suitable for young children under 7 [Bruckman and Bandlow, 2002, p. 7].
 - (b) **Tablet PC**
 - **Advantage:** Increasing presence and availability. Intuitive touch interaction.
 - **Disadvantage:** Size of the device could be too small for a simultaneously interaction of a group bigger than 2 children.
 - (c) **Beamer + MS Kinect⁸**
 - **Advantage:** Real big screen and interaction area. Natural interaction via body tracking (movement and/or pointing)
 - **Disadvantage:** Screen/interaction area is projected on a wall (depending on its size) children could maybe not be able to interact with the complete interaction area.
 - (d) **Multitouch Table**

⁸<http://www.microsoft.com/en-us/kinectforwindows/>

- **Advantage:** Big interaction surface suitable big for a group. Typical set up for group collaboration. Intuitive touch interaction.
 - **Disadvantage:** Height and surface size of the table could limit the ability of the children of interacting with and to see the whole screen/interaction area. Availability of a multitouch table is in most cases limited and the asset costs are quiet high.
4. **Interaction** Even though no platform has been chosen yet we have a tendency to an interaction concept in the direction of intuitive touch or natural gestures. Following types of user interaction input seem suitable:
- (a) **Touch** Direct input via touch has been proven to be a great and intuitive way for children to operate technical devices.
 - (b) **Body Tracking** Using natural gestures and body movements as interaction input becomes more and more popular since body tracking has become easier via technologies like the Microsoft Kinect or the LEAP Motion controller. It is very natural since it is the way we interact with our environment every day.
 - (c) **Stylus** A stylus could be an intuitive (additional) type of interaction considering the potential option to draw within the application.

3.4 Conceptual Try-out

In the previous section we discussed a collection of possible features and functionalities of an application that stimulates divergent thinking and consequently creativity as well. Implementing all functionalities within this application is not a good choice since some functionalities are maybe conflicting with each other and the implementation of others would exceed the available time for this project.

A try-out with children from a local kindergarten and interviews with their nursery teachers was set up to select which functionalities to include. The next subsections will cover a short description of the intention, execution and conclusion of this try-out.

3.4.1 Starting Point

For the try out the following initial questions were formulated:

1. **The game mode for the story symbols** Which mode is actually favored by the children? (See point 1a on p.7)
2. **Drawing or not drawing?** Is it supporting or enhancing the creative process? Or is it grabbing the focus from and disturbing the actual story telling task? (See point 4 on p.7)
3. **Story Characters** Is the involvement of some kind of character adding value to the story or improving the experience for the children? (See point 3 on p.8)
 - (a) **Child book characters** or
 - (b) **Own created — Super-self**

3.4.2 Try-out

The "DRK Kinderwelt", a kindergarten financed by the German Red Cross organisation, situated in Borken - Burlo, Germany was so kind to allow us to visit them. The try-out took place on May 5, 2013 and started at 9 am. We cooperated/played together with the children and teachers of the "Regenbogen" group. They had some experiences with Rory's Story Cubes before. Here the rough course of the try out:

- Short introduction talk with the kindergarten teacher. (But not mentioning details of the final concept)
- 1. Try-out: Story Cubes with around 5 year old children. In the second round with additional documentation of the story through drawing the interpretation of the symbols down on carton cards.
- 2. Try-out: Playing with the story Cubes with around 4 year old children
- 3. Try-out: Playing with the story Cubes with around 5-6 year old children (who will start primary school in summer)
- Interview with kindergarten teacher (Introduction to the actual concept, several questions)

The try-out has had a very useful outcome, so that we could make some conclusions regarding our design choices, described in the next section.

3.4.3 Conclusion of the Try-out

From the try-outs together with the children we could clear following points from our list:

1. **to 1:** The soft-liner approach worked better for a group set up and collaboration. The story telling was so already split up in parts and the children could more easily take the turn and tell the next part. It made the collaboration more dynamic.
Considering this we decided to go for an implementation of the soft-liner approach, since we are sure it results in a better group collaboration and higher demand in creativity.
2. **to 2:** Letting the children draw during the story generation process distracted them significantly and pulled them out of the story telling task (especially if several drawing colours were offered). The kindergarten teacher or we had then to recap the story until the current point to guide them back to the actual task.
This was a clear indicator not to include the option to draw during the generation process. Adding and enriching the story afterwards with drawings could be still worthwhile.
3. **to 3:** Bringing in characters as another variable that has to be included within the story clearly limited the number of directions the story could take in comparison to the stories created only using the story cubes. The children took longer to come up with the next story fragment and the outcome was also not perceived as creative as before by the kindergarten teacher and us.

Seeing this we were sure that the increased attractiveness by added own or child book characters can not outweigh the negative consequences they have on the diversity and shown creativity of the stories. Since enhancing creativity is our aim with this application including characters became out of question

After the try-outs we had a further explanatory talk and interview with the kindergarten teacher. We explained her the aim and possible concept of the application, asked for feedback on this and asked also more general questions that could be helpful to make decisions for the concept and the whole project. The most important aspect are listed here:

1. **”Repetition is important for children.”** This fact proves the documentation functionalities to be very worthwhile. Using those functions the children can recap and rethink their stories. The kindergarten teacher judge a documentation function also as attractive since it is something she can not offer easily with the story cubes. The necessity for repetition leads us to another advice of her:
2. **”Keep it simple.”** She advised us to limit the functionality really to a basic set and concentrate on the main functionality, the story generation. Having too many options, elements and functionalities could get the children easily lost in the application and would not make them repeat the same task or process again.
3. **The most suitable set up for group collaboration: ”A table is a good set up for group work.”** This confirms our already present opinion that a multitouch table could be a good set-up for our application.

For all details of the try-out see appendix A on p. XLII.

3.5 State of the Art

Before coming to the actual design choices, we investigate a number of related projects.

A similar prototype as we intend to create during this project was implemented in 2004 at ITC-irst, the department for scientific and technological research of the former ”Istituto Trentino di Cultura” (ITC), now known as ”Fondazione Bruno Kessler” (FBK), in Trento, Italy. Their prototype also called ”StoryTable” was as well ”aimed at supporting a group of children in the activity of storytelling” [Cappelletti et al., 2004, p. 1]. However the focus of their research was more on cooperative learning and collaboration of the children. Accordingly, their design was centered on features like multi-user interaction and also individual tasks but only offered a small set of story elements and characters to choose from. Our story table will be mainly designed to enhance children’s creativity and will have a big set of story symbols with a high variation in topics. In our concept group collaboration is supposed to be an positive influence on the story generation process, getting all group members actively participating. Nevertheless having their experiences and evaluation methods of their trials in mind could be worthwhile for the further course of this project [Cappelletti et al., 2004, p. 3].

When it comes to a commercial distribution of multitouch tables in the educational sector, SMART (also known for the SMART Board) do have the SMART Table⁹ in their product portfolio. The newest version is special constructed to be used by children and in classrooms:

- Different interactive and adaptable applications are available.
 - Realized also through developer community and the provided software development kit (SDK)
- It enables collaboration within groups of up to 8 children.
- The multitouch surface/screen is scratch- and spill resistant.
- The table is "accessible for all", also with a wheel chair.

The SMART Table is insofar interesting for future work with the Story Table, that it could be worthwhile to make the Story Table application available on the SMART Table using their SDK. In this way it would become easily distributable and available to an already existing client base.

⁹<http://smarttech.com/table>

4 Product Specifications

After exploring, ideating, diverging and converging ideas with the help of feedback from the target group, experts and work and experiences of predecessors we are now able to make concept decisions.

4.1 Design Decisions

In the section before we generated a broad collection of possible specifications, elements and functionalities for our concept (see p. 7). In the following we will define a fixed concept and design specifications for our application that we can work on. But before we go into detail about the final functionalities of the application we have to define the external parameters.

- **The Name**

We named our application simply Story Table without being conscious of the work of our predecessors from ITC-irst with an equal name on that point in time [Cappelletti et al., 2004, p. 3].

- **The Platform**

Our choice for a multitouch table as platform (as already indicated in the name of the application) became very obvious considering our earlier thoughts, the opinion of the kindergarten teacher (see section 3.4.2) and the work of predecessors. They state for example that a multitouch table like the before mentioned SMART Table is optimal for collaborative educational games due its optimal big surface which enables simultaneous interaction and a well balanced contribution and its intuitive interaction method [Warnecke et al., 2011, p. 1].

- **The Users**

As stated in section 2.1 the target group are "children in a pre-school age on the edge to start primary school (4-6 years old)". But after considering the experiences made in the try-out described in section 3.4 it became clear that children in the age of 4 need still much guidance of an adult person during the story generation process and will most likely not use the Story Table independently as intended. On this reason we adapt the age of our target group to a age of 5-8 years. In addition we fix our decision to design the application to be mainly used by a group of children. It is simply the setup a high percentage of work is done in in *real* life especially when it comes to school activities [Resnick et al., 2005, p. 5]. Furthermore "cooperative story telling can increase the level of engagement of less motivated [and potentially also introverted] children" and in general promote their learning process [Warnecke et al., 2011, p. 1, 2]. Successful creative concepts are most often a fusion of ideas from different people. Creativity seems to be not just one isolated process within the head of one person "but [...] a cultural and social event" [Makel and Plucker, 2008, p. 249] where people exchange and contribute to the ideas of others. Having this in the back of the head it is only logical to design for a group. We will aim for a group size of 2-4 children, since interaction on the multitouch table seems comfortably possible with a maximum of 4 persons.

From the list of functions defined before (see p. 7) following made it into our application concept:

1. **Random Story Symbols** as the main element of the Story Table transferred from the Story Cubes. They will be randomly provided one after each other following the soft liner strategy (based on point 1 on p. 12 and [Resnick et al., 2005, p. 5]).
 - (a) **Amount of Symbols** Different choices for the amount of symbols are possible. The Story Cubes give 9. It would be as well possible to make the amount of symbols depending on the amount of players, or let the children decide. In order to keep the interaction simple and to keep the story generation rather short and dynamic than long and attention demanding, we choose to let the application decide to provide randomly 4, 5 or 6 symbols [Resnick et al., 2005, p. 9].
 - (b) **Story Symbols Categories** The set of story symbols included in the Story Table application should contain symbols from various domains. This increases together with point 1a from the next list the level of difficulty to connect the symbols and make up a story.
2. **Symbol Skills** Animated skills (like throwing water or fire, fly around, jump, etc.) are attachable to the story symbols to add even more combination possibilities and foster the interaction between them. (see point 2 on p. 8).
3. **Story Documentation** Besides deciding against additional drawing during the story generation, since it distracts from the story telling, we still judge a digital rich documentation of the stories as really worthwhile. Therefore we made the choice to record the speech around the Story Table and the movement and interaction of the story symbols on its screen to document the stories.

This set of functions is significantly reduced in comparison to the previous set based on the advice of the kindergarten teacher, the paper "Design Principles for Tools to Support Creative Thinking" [Resnick et al., 2005, p. 7] and considering the feasibility of the application in scope of this project in mind.

4.2 From Design Decisions to Functional Specifications

The above described elements and high level functionalities of the Story Table will consist out of smaller and lower level processes and tasks within the actual application.

1. **Start A New Story** The children must be able to start a new story, which will be added to their collection if it is finished. Each story must have a random amount (between 4 and 6) of randomly chosen story symbols before entering the story generation mode.
 - (a) **Generate A Random Set of Story Symbols** The Story Table application must be able to generate a random set of story symbols as well as take care that not all symbols are from the same category to ensure that a higher amount of creativity is need to connect them within the story.
2. **Story (Generation) Mode** In the story generation mode (further also called just story mode) the children must be able to demand and get a new story symbol from the application, until all story symbols chosen for that story are on the screen. The story symbols should be interactive and an animated skill should be attachable to them. The application must capture and save the story during the whole story generation process.

- (a) **Interaction with Story Symbols** The story symbols must be moveable by the user to arrange them on the screen or play around with them to tell their story. Furthermore they should be selectable to add a skill to a specific symbol. For further details on the interaction design please see section 4.3.1.
 - (b) **Attachment of Symbol Skills to Story Symbols** The application should be able to offer the possibility to select and attach a skill to a selected symbol. Consequently the system needs to display the animated skill paired with the symbol, move it along with the symbol and play the animation for a defined duration.
 - (c) **Recording A Story** During the whole story generation mode the system must capture the change in position of the story symbols and additionally which skills were played and paired with those. Those facts have to be captured together with the moment in time in which they happened.
3. **Select and Play Back a Previous Generated Story** The Story Table must provide an option to select a previous generated story and play it back.
- (a) **Select A Previous Generated Story** One (sub)menu must be contained in the application that displays representation of all previous stories. The representations should be uniquely in their graphical appearance so that it is clear for which story they stand for.
 - (b) **Story Play Back** After the selection the story, consisting of the previous recorded speech and screen content must be played back. In optimal case they should be completely synced in their appearance in time.

4.3 User Experience Requirements

The Story Table should next to its main purpose as support tool to enhance creativity be an enjoyable and fun application the children like and want to use [Resnick et al., 2005, p. 2]. The story telling happening through and between those children should be the main task and the application should stand in the background as an easy to use and encouraging supporting tool. That means that the application especially within the story mode should not offer any distractions that could get the children out of the story generation flow on the one hand and on the other hand should have a good thought through interaction design as described in the next section.

4.3.1 Interaction Design Requirements

The chosen multitouch table provides already a very intuitive type of interaction. But this aspect needs to be supported by an as well intuitive and suitable graphical user interface (GUI) to reach its full potential. To create an easy to use interface for the Story Table following aspects need to be considered:

1. The user should be able to perform following **actions**:
 - (a) **Press** the buttons of the GUI to control the functionalities of the Story Table.
 - (b) **Move** the story symbols freely to arrange them on the screen.
 - (c) **Select** a story symbol (only one at a time) to attach a symbol skill to it.

2. The performable actions should be *self-revealing* or already familiar to the user or at least fast and easy to understand- and adaptable for them [Resnick et al., 2005, p. 2].
3. The GUI should provide a **suitable feedback** (acoustic and/or visual) to make clear what the user has effected.
4. The **size** of the different elements of the GUI needs to be in proportion to the size of the screen and must be appropriate for the interaction with children.

How these aspect of the graphical user interface, the whole user experience and the functionalities of the Story Table are implemented will be handled in the next section.

5 Product Realisation

5.1 Soft- & Hardware Choices

The realisation of a prototype for an application depends strongly on the basic choices for the main soft- and hardware implementation. In most projects these choices are underlying some limitations.

1. **Hardware: Multitouch table** — Fortunately the Human Media Interaction research group at the EEMCS department at the University of Twente owns two different multitouch tables and was willing to grant access to one of them. We choose for the version using the principle of rear diffused illumination¹⁰ for the detection of touch interaction (see figure 4). The working principle is as follows: Illuminators shine infrared light from underneath on a diffuser also functioning as projection screen. If an object touches the surface of the diffuser more infrared light is reflected. This can be sensed by an infrared camera and can be interpreted as touch interaction.
2. **Software: Programming language** — Due to familiarity and experiences it was decided to use C++ and the openFrameworks toolkit¹¹. openFrameworks offers a comfortable implementation of visualisations and media playback and also a wide range of addons for a wide variety of applications since it is open source.



Figure 4: The multitouch table of the HMI research Group using the Rear Diffused Illumination principle.

5.1.1 Connecting the Components

I/O device for our application is the before mentioned multitouch table. The TUIO standard¹² developed for this kind of applications simplifies the connection of them significantly. In this

¹⁰<http://wiki.nuigroup.com/DiffusedIllumination>

¹¹<http://www.openframeworks.cc>

¹²<http://tuio.org>

standard only a TUIO server and client is needed. The TUIO server interprets in our case the picture of the infrared camera, wraps the touch events into TUIO messages and sends them over a port (typical 3333) to the client. The TUIO client receives those messages and unwraps the content like position, size etc. of the touch event to be used by the end application.

After some research we found the Community Core Vision¹³ open source project, a TUIO server for multitouch tables developed by the NUI Group Community¹⁴ with openFrameworks also suitable for our table. As TUIO client we will use an openFrameworks add on called ofxTuio¹⁵ developed by Patricio Gonzalez Vivo¹⁶. First try-outs connecting the multitouch table with an simple openFrameworks application were successful.

5.1.2 Enabling the Realisation of All Functionalities

Besides the connection between hardware and software it can also be critical to ensure that all functionalities of the concept can be implemented within the prototype application. Fortunately the openFrameworks community provides, as already mentioned, a great variety of so called ofxAddons¹⁷. Following add ons were chosen for the implementation of certain functionalities that are not covered by the openFrameworks core library:

1. **ofxQTKitAVScreenRecorderr** → to implement the function: *Recording A Story - Sound & Screen Recording* (see point 2c on p. 17)
2. **ofxFlashLite**¹⁸ → to implement the function: *Symbols Skills - Animation* (see point 2b on p. 17 and point 2 on p. 8)

5.2 Structure and Features of the Graphical User Interface

The application and software architecture described in the sections here after were designed according to the GUI structure and hierarchy captured in the graphic in figure 5 and in the following list:

1. **Main Menu** The main menu will contain one button to *Start A New Story* (see point 1 p. 16) leading to the *Story Mode* menu and furthermore a representation for every previous recorded story (see point 3a, p. 17) containing a screenshot of the story to make them identifiable leading to the *Story Player* menu.
 - (a) **Story Mode Menu** The story mode menu has a button to demand a new story symbol (see point 2 p. 16), which is deactivated for a specific duration after it was pressed to ensure that children engage with the new appeared story symbol for a specific duration. It will further disappear completely if all available story symbols were demanded. In addition a button leading to the *Skill Selection* menu to add a skill to a story symbol is present if one symbol is selected (see point 2b, p. 17). A button to finish and save the story is always present leading back to the main menu.

¹³<http://ccv.nuigroup.com>

¹⁴<http://nuigroup.com/go/lite>

¹⁵<https://github.com/patriciogonzalezvivo/ofxTuio>

¹⁶<http://www.patriciogonzalezvivo.com>

¹⁷<http://ofxaddons.com>

¹⁸<https://github.com/julapy/ofxFlashLite>

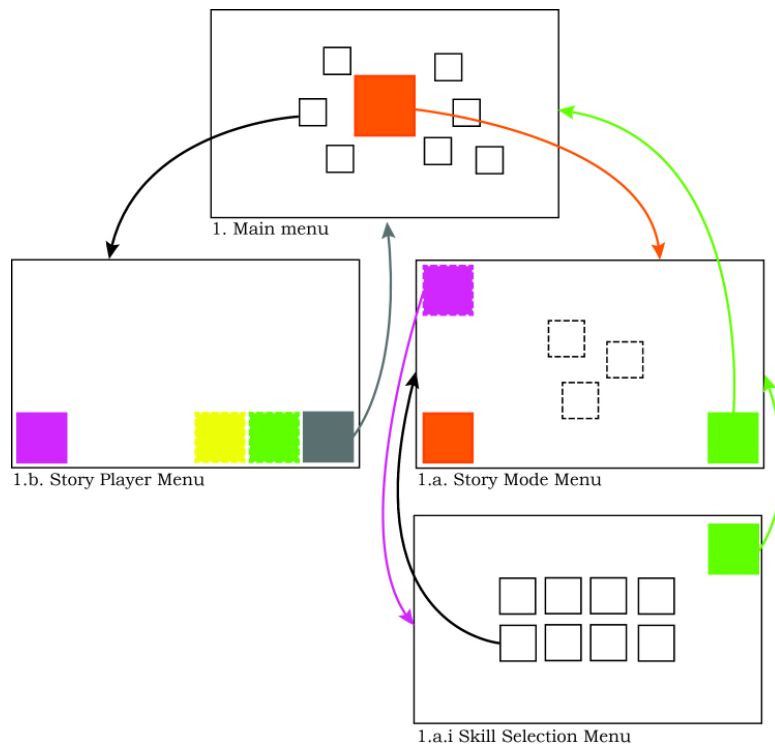


Figure 5: Flow chart of the different menus of the Graphical User Interface. (Elements with a dotted border are non-static)

- i. **Skill Selection Menu** In this menu representations of all available skills are displayed. Pressing one representation means attaching this skill to the story symbol selected in advance and going back to the story mode menu (see point 2b, p. 17). Another button just leads back to the story mode menu without attaching a skill.
- (b) **Story Player Menu** plays back the recorded story that was represented by the button pressed before in the main menu (see point 3b, p. 17). Furthermore buttons to start, pause or go back to the beginning of the play back and also one to exit the play back and go back to the main menu are displayed.

5.3 Software Architecture

The software architecture for the Story Table application was planned according to the *Model-View-Controller*(MVC) approach [Krasner and Pope, 1988]. Basic principle is to sort and separate the functionalities of an application into the three categories: the *Model* is responsible for the data/ the content of the application, the *View* is responsible for the I/O of the application (means the GUI interface and detecting interaction input) and the *Controller* which is in charge of processing and storing data, responding to interaction inputs and executing functionalities. In this way classes like e.g. the view classes could be reused for another (equal) application later on since the GUI interface is not depending on the data displayed or the functionality behind it.

This leads to a software architecture with the following structure (see figure 6 for a simplified class diagram):

- **Model**

- ***storyModel class*** — This class stores the data necessary to generate and play back a story. Every time a new story is started a *storyModel* instance gets created equipped with a set of random story symbols in form of *objectInfo* structures and stored within a vector. Those get requested by the *controller* and the stored information like file path to symbol graphic and graphic size are handed over to the *view* to display them.
- ***objectInfo structure*** — This structure stores the file path for the story symbols the category of the story symbol and optional the display size for the graphic.

- **View**

- ***view class*** — This is the superclass for the views. It owns, displays and manipulates *uiElement* instances that are stored in three vectors. It also contains the basic interaction detection functionalities. It gets a list of TUIO points (touch events) from the TUIO client and detects which interaction point is (still) on which *uiElement*. Those interaction information get stored in *interaction* structures and these get stored in the *interactions* vector owned by the controller. The *view* is also responsible to delete interaction structures that are not existing anymore. Following subclasses were created for the different menus of the application:

- * ***mainMenuView class***
- * ***storyModeView class***
- * ***skillMenuView class***
- * ***storyPlayerView class***

- ***uiElement class*** — This class is designed to display a graphic to represent data or functionalities of the application. The display of the the graphics can be manipulated in size, position and appearance. For the different kind of user interface elements three different subclasses were derived:

- * ***uiElementButton class***
- * ***uiElementSymbol class***
- * ***uiElementSkill class***

Those are stored within the *buttons*, *symbols* and *skills* vector in the *view* class.

- ***interaction structure*** — This structure is made to store interaction information like the ID of the *uiElement* the interaction was detected on, starting time of the interaction, whether the interaction has been part of an multitouch gesture, etc.

- **Controller**

- ***storyTable class*** — This class controls the whole application and owns on this reason (multiple) instances of the classes and structures described earlier in the *Model* and *View* section. This class handles the interaction events stored by the current view instance in the shared *interactions* vector and performs the according actions. It furthermore has the ability to start and record a new story, to load and play back the screen recording of a story, etc. For a detailed description of the contained class instances and functionalities please see appendix p. XLV.

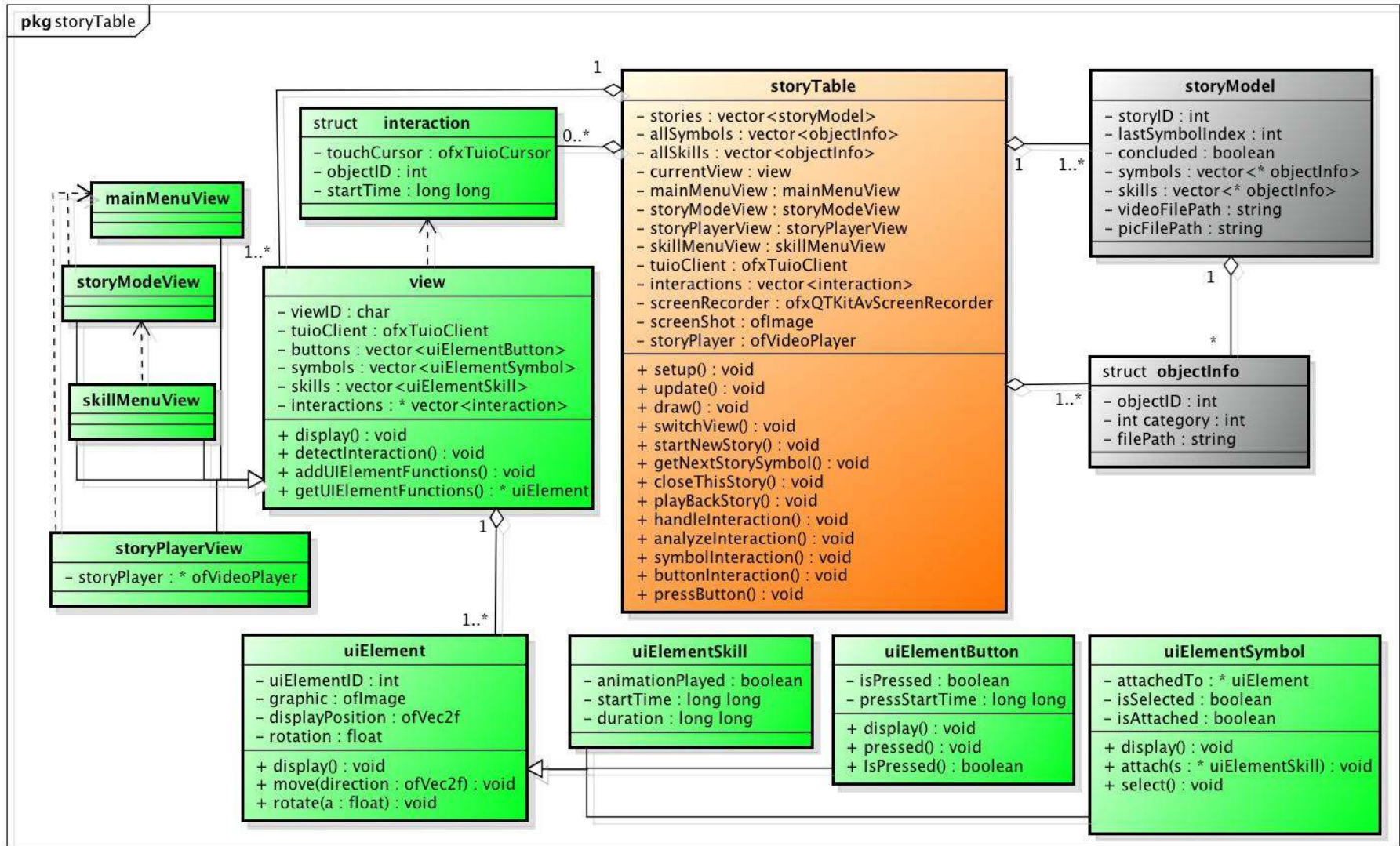


Figure 6: Simplified class diagram of the implemented software architecture using the MVC principle. (M = grey, V = green, C = orange)

5.4 Communication between Model, View & Controller

In the original MVC paradigm communication only exist between Controller \leftrightarrow Model and Controller \leftrightarrow View but no direct communication between View \leftrightarrow Model. Since our Model is static and only manipulated by the Controller there is only one way communication in form of orders and requests of the Controller present. This is different between Controller \leftrightarrow View since the View is responsible for the detection of user interaction and needs to give this information further to the Controller that handles this interaction. Since the Views in our application are instances within the storyTable instance they can not directly communicate with the storyTable instance. Exception would be a regular call of a method of the view instance that gives back a (pointer to) a vector with the interactions. We decided instead to create a shared vector for the interactions owned by the storyTable instance. The View has a pointer to this vector and updates it every time that view is called to display its content.

As it maybe already became clear earlier the Story Table application uses unique IDs to identify *uiElement* instances and to determine for which data or functionality they stand for. These IDs are defined within an index that is known to all class instances in the whole application (see appendix p. XLVI for the index).

For a better inside in the working processes between view, controller and model in the following two examples.

5.4.1 Process Descriptions

- **Demanding A New Story Symbol**

Prerequisites:

- The application is in the Story Mode Menu.
- The user has touched the button "ADDSTORYSYMBOL". (ADDSTORYSYMBOL is the alias of the ID of the uiElement representing the functionality to add a new story symbol (see appendix p. XLVI))
- The touch event is correctly recognized and interpreted by the TUIO server.

Triggered processes:

1. The *StoryModeMenu* recognizes the touch event on the button ADDSTORYSYMBOL and stores the position and start time of the interaction together with the ID of the involved *uiElement* in an *interaction* structure within the *interactions* vector.
2. The *storyTable* instance handles all interactions within the interactions vector every cycle via the method *handleInteraction()*. In our case following functions would be called in the further course:
 - (a) *analyzeInteraction()* \rightarrow uiElement is *uiElementButton*.
 - (b) *buttonInteraction()* \rightarrow Button is not deactivated. Interaction is possible.
 - (c) *pressButton()* \rightarrow Performs the actions according to the object ID as elaborated below:
3. Calling *pressButton(ADDSTORYSYMBOL)* results in the following actions:

- (a) Play sound feedback for the button.
 - (b) Call function *getNextStorySymbol()*
 - (c) Deactivate the *uiElementButton* instance with the ID "ADDSTORYSYMBOL" for 10 seconds.
4. *getNextStorySymbol()* performs following actions:
 - (a) Tests whether the current story is not concluded.
 - (b) If not, it gets the needed data for the new story symbol from the current *story-Model* object.
 - (c) Passes the information over to the *StoryModeMenu* instance which creates and adds a new instance of an *uiElementSymbol* to itself.
 5. The new story symbol will appear on the screen in the next cycle. If the story is now concluded (all story symbols are on the screen) the button to request a new story symbol will disappear.

• Attaching A Symbol Skill to a Story Symbol

Prerequisites:

- User selects a story symbol and enters the Skill Selection Menu.
- The User selects one symbol skill by pressing its representation.
- The touch event is correctly recognized and interpreted by the TUIO server.

Triggered processes:

1. The *storyTable controller* analyzes the interaction similar as in the previous description up to the call of the method *buttonInteraction()*
2. *buttonInteraction()* recognizes that the representation of a symbol skill was selected and calls *addSkillToSymbol(uiElementID)* with the matching ID and returns back to the story mode menu.
3. *addSkillToSymbol()* has then performed the following actions:
 - (a) Translate the *uiElement* ID to the correct *uiElementSkill* ID.
 - (b) Get the *uiElementSkill* instance matching the *uiElementSkill* ID and attach it to the selected *uiElementSymbol*.
 - (c) Deselect the *uiElementSymbol*
4. On the next touch event on the *uiElementSymbol* attached to the *uiElementSkill*, the *uiElementSkill* gets its display position and starts playing the animation.
5. Now the *uiElementSkill* gets displayed and moved along with its *uiElementSymbol* for the whole animation duration.
6. If the animation duration has passed the *uiElementSkill* gets automatically detached from the *uiElementSymbol* and a new skill can be attached.

5.5 Design Changes, Compromises & Challenges

During the implementation of the Story Table application some challenges arose and resulted in the design compromises and changes listed below:

1. No Cross-Platform Support

Problem: The operating system of the hardware we developed on has been Mac OS X. Most of the explorational implementation try-outs happened on this operating system. As it turned out some openFrameworks add-ons we used during the planning of the implementation are not working on a Windows operated machine since they were developed under Mac OS X and e.g. need specific QuickTime¹⁹ libraries only available for Mac OS X.

Solution: Easiest solution for this problem was to find a Mac operated machine having all ports to connect all necessary components of the multitouch table to (especially the infrared camera that is connected via Fire Wire 400²⁰). Luckily the SmartXP lab owns a Mac Pro that comes with a Fire Wire 800 connector. With help of several extension cables and a Fire Wire 400 to 800 adapter we could connect the infrared camera, the beamer and the speakers of the table to the Mac Pro.

2. No Working Audio Recording Add-on

Problem: After several tries getting different openFrameworks add ons for audio recording to work, we realized that we face a bigger challenge implementing the recording functionality.

Solution: This problem was indirect solved by a change within the software architecture. Actual it was planned that the application tracks the change in position of the story symbols, which skills were attached and record the audio in parallel. It was designed in this way to enable a change of the story by the children afterwards. But during a discussion with the supervisor Angelika Mader on the implementation it became clear that this architecture is overkill for the current desired functionalities of the prototype. The software architecture was changed to the current one (described in section 5.3) where the recording of the story is done by a screen recording that includes audio (see appendix p. XLVI for the class diagram of the old architecture). This made an separate implemented Audio Recorder unnecessary.

3. Insufficient Functionality of *ofxFlashLite* Add-on

Problem: While the first try-outs of the *ofxFlashLite* add on (see section 5.1.2 point 2) had some very pleasing results it turned out later that the animations are not position-, scale- or rotatable from within the openFrameworks application. Since the animated skills must move and rotate along with story symbols to guarantee a clear connection between them a new strategy to animate the skills had to be found.

Solution: In the end we decided to create some basic animations ourself within the borders of the openFramework core libraries. Due to this fact only two skills (throwing fire or water) were available in the prototype application different than initially planned.

¹⁹<http://www.apple.com/quicktime/>

²⁰<https://developer.apple.com/hardware/drivers/>

5.6 Audio Visual Design

The audio visual design are the main contributors to the user experience within the application and play therefore an important role for its success. As stated in section 4.3 the application should stand in the background as supportive tool of the story telling. On this reason the graphics and sounds of the applications should make a clear statement about the represented functionalities and should only grab as much attention as needed to be operated. The audio visual statement of the application will be thus simple and sober only using some accents in bright colours and engaging sounds and melodies to create a pleasing and enjoyable experience.

For the realization of the graphical design we first cooperated with an external illustrator. Sadly this cooperation had a not optimal and incomplete outcome due to communication problems and unreliability (see appendix section B.2.1 for the results of this cooperation). This is also one factor that lead to the first unsuccessful user evaluation session. With the experiences we gained during that session in mind, we decided to rethink and redesign the complete visual design and support it furthermore with background music and audio feedback.

5.6.1 Visual Design

We want to achieve the above mentioned clear- and soberness of the visuals by following the current trend in interface design of a flat and minimal design. This approach claims to be easy read- and understandable by the user keeping the functionality in the foreground. Providing a high usability and meeting our requirements for the interaction design of our application (see section 4.3.1 e.g. requirement 2). Typography has also a big role in this flat design movement, however in our design text will be totally absent since parts of our target group are not able to read and we do not want to limit the access to the application by the used language. As an example of the general visual design the icon for the Story Table application is shown in figure 7.

To ensure coherence and harmony in our design we defined the color scheme in figure 8. These are the colours used for most graphical elements, additionally used colours were chosen harmonizing with them.

Most of the elements in our interface design were taken from or created on the base of one of the two following icon sets we bought for this project:

- *Monicons 1* by Tim Boelaars²¹
- *othercircles* by Lubos Volkov²²

For a overview of these icon sets see appendix section B.2.3. Here after a more detailed description of the design details of the different elements:

²¹<https://creativemarket.com/timboelaars/3305-Monicons-1-100-icons>

²²<https://creativemarket.com/otherplanet/6567-othercircles-unique-icon-set>



Figure 7: The icon of the Story Table application.



Figure 8: Color scheme for the graphical user interface. See appendix section B.2.2 for the specific RGB values.

Navigational and Operational Elements

- **Size:** 10-20% of the screen width - depending on the size of the graphic - forms an appropriate sized touch target on the projection area of our multitouch table (fulfilling requirement 4, section 4.3.1).
- **Placement on the Screen:** The elements for navigation through and operation of the application are placed with respect to the additional content displayed in the specific menu. They are preferably placed in the corners and on the long sides of the screen to provide as much free space as possible to display content or as working space. In menus only consisting out of navigational elements these are more spread over the whole screen with a tendency to the center to enable access from all sides of the table.
- **Colours:** The bright colours of the color scheme were used for these buttons to focus the attention of the children on them (see figure 9 for some examples).

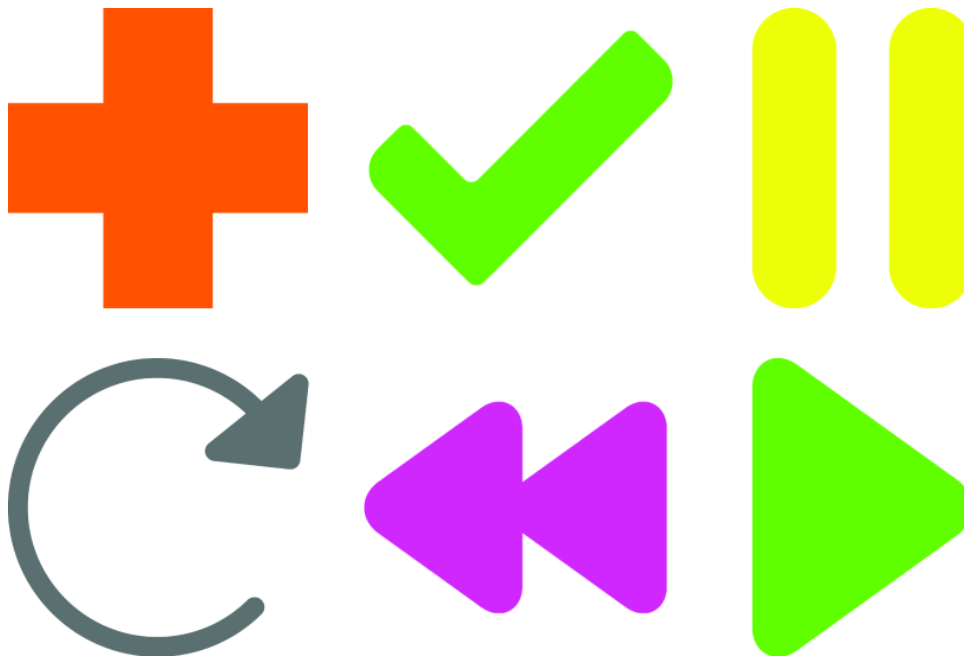


Figure 9: Some examples of bright colourful buttons.

Story Symbols

- **Size:** 8-18% of the screen width - on reasons already stated before and additionally to have enough space left to move the story symbols with a maximal amount of 6 present on the screen.
- **Placement on the Screen:** The story symbols are in general freely moveable on the screen except the reserved positions for the interface elements to avoid interference in the interaction handling within the application.
- **Colours:** The symbols are only black and white on purpose to keep a high interpretability and avoid distraction from the story generation activity (see figure 10 for some examples).

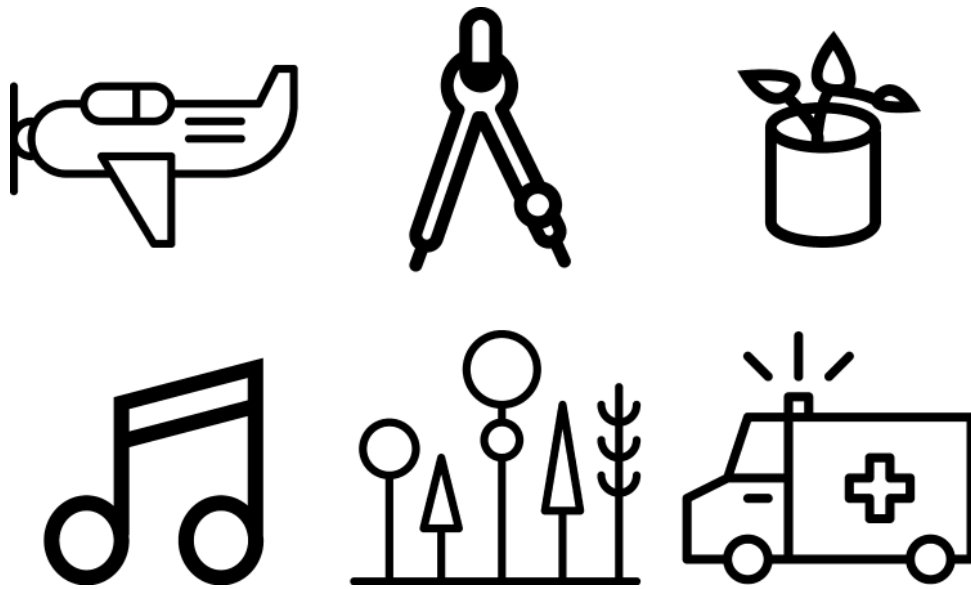


Figure 10: Some examples of the simple pictogramic story symbols.

Symbol Skills

- **Size:** The animated skills are scaled in proportion to the story symbols they are attached to and their range is big enough to enable interaction between the symbols.
- **Placement on the Screen:** They are also moved along with the symbol they belong to and can also leave the screen and overlap with the user interface elements since there is no direct interaction foreseen for them.
- **Colours:** The symbols are created with openFrameworks along with the flat design approach and harmonizing with the defined color scheme (see figure 11 for an example).

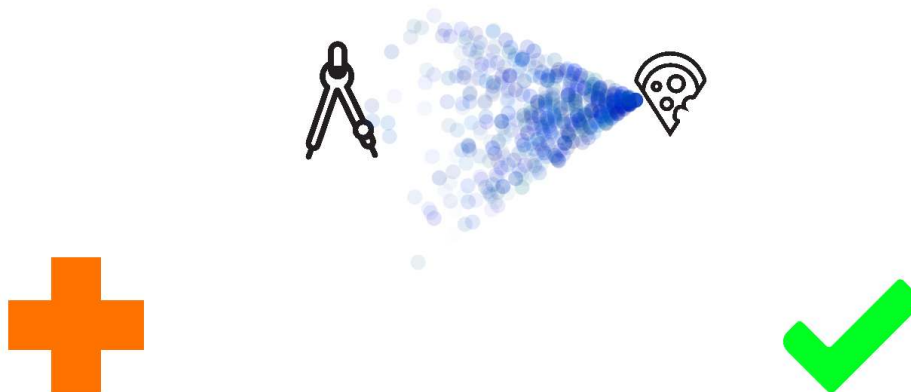


Figure 11: A screenshot of the *water throwing* animation attached to a slice of pizza.

5.6.2 Audio Design

Adding sound to an application extends the user experience to another sense, the hearing. Music claims to be very influential on the human mind and mood. On this reason we decided to add some background music to the main menu. One out of three music tracks will be randomly chosen and start playing when entering the main menu. The mood of the songs is defined from happy to easy going and a little bit arcane considering the mood the set up will be placed in during the user evaluation. We only added music to the main menu due to the fact that background music would be disturbing and distracting during the story generation and the story play back.

Acoustic interaction feedback is implemented through out the whole application to give immediate feedback to the user on their chosen actions. The selected sounds are discretely and pleasing as well taking the rate of their occurrence into account. Furthermore we allocated more complex sounds to higher level processes like starting or finishing a new story and more simple sounds to lower functionalities like demanding a new story symbol or attaching a skill to a symbol.

6 Evaluation

6.1 Functional Testing

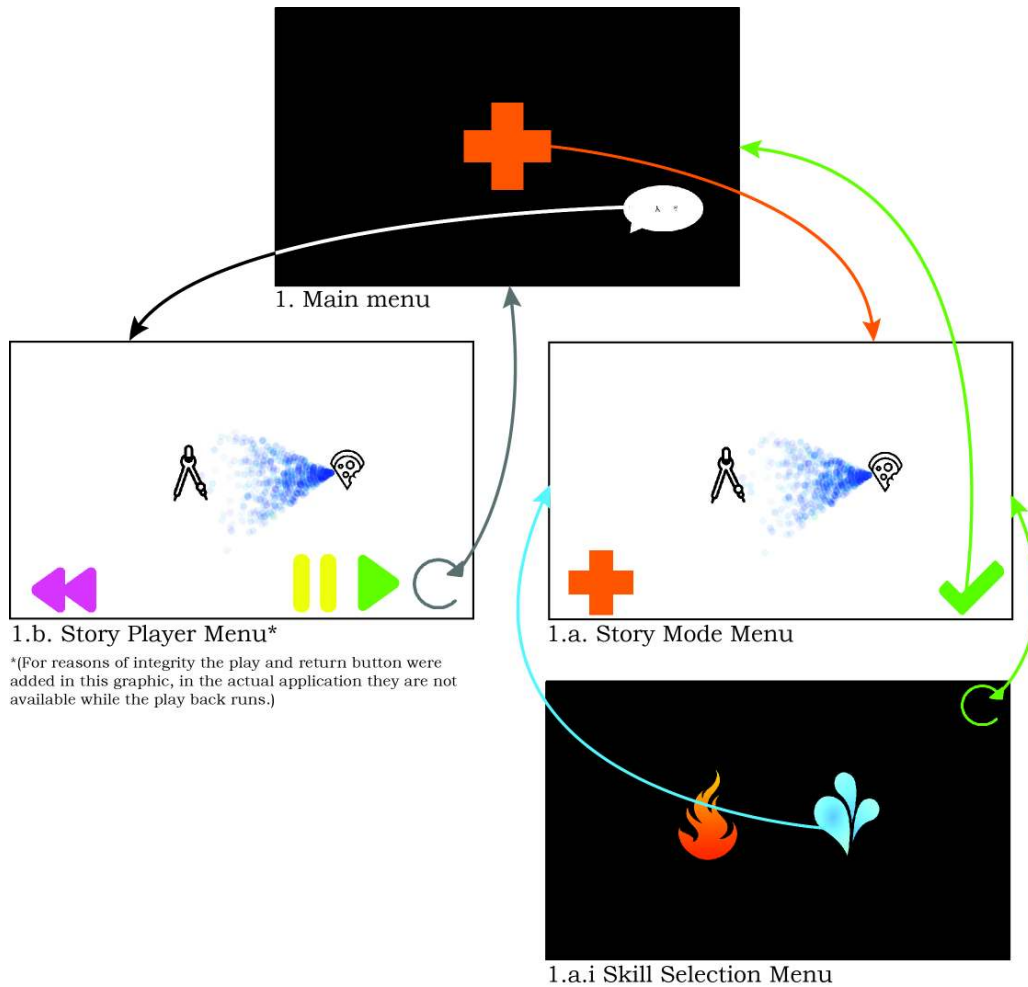


Figure 12: Overview of the different menus of the Story Table application.

The in section 5 described realization resulted in a prototype that matches the functional specifications in section 4.2. The prototype meets not only our expectations in functionality but also when it comes to the generated user experience. An overview of the final application is provided in figure 12 and the final set up is shown in figure 13.

Nevertheless since the Story Table would need some further development until it is a releasable product some minor errors and bugs caused by the soft- and/or hardware are still occurring:

1. **Application crashes due to some invalid file paths** During the user evaluation (see section 6.2) the application crashed a few times caused by typos in some of the file paths of the graphics for the over 150 story symbols. This was very inconvenient but was sadly not fast fixable during the evaluation session. By now this issue should be resolved.
2. **Non proportional movement of the story symbols** As described in section 4.2 the story symbols should be moveable and arrangeable on the screen. This should happen



Figure 13: Set up of the Story Table Application for the User Evaluation.

according to the actual touch interaction on the surface of the table. This functionality is working in principle but not optimal. We are not totally sure on the cause. Nevertheless sometimes it happens that the user loses the story symbol while moving it. This is might caused by the fact that the TUIO server transmits the TUIO messages on a higher frequency than the program is executed, since we did not had this phenomenon in the smaller test application for the *viElements*. Further insights in this problem have to be made to solve it.

3. **Non reliable input from the infrared camera** After a while the fixation of the infrared camera in the multitouch table got loose. This lead to an incorrect alignment of the camera to the diffuser, which resulted in strong deviation of the actual touch position on the table and the one the Story Table received from the TUIO server. We tried to fix this temporally but the fixation always got loose again. Especially when someone bumped against the table. This unfortunately mostly occurred through the usage by children like during the evaluation session.
4. **Non precise detection of touch events** The HMI multitouch table needs a good calibration taking its user and the environmental circumstances of its location into account. In this way the TUIO server can deliver decent touch events but touch events through fingers and smaller objects are still hard to detect and most likely have a more significant position offset then touch events of bigger objects.

Even if these are minor bugs for a first prototype of an application they are influencing the user experience significantly, and especial children can be sensitive if something does not work the way they expect it to. Nevertheless we judged our prototype suitable to be tested by our actually target group. The preparations and the actual execution is explained in the section here after.

6.2 User Evaluation

6.2.1 Evaluation Question

For a worthwhile user evaluation towards our refined research question as stated in section 3.1.3 some more concrete question on the different aspects of the Story table are formulated:

1. Is there already an advantage just through the transfer of the Story Cube concept and all its features into the digital domain?
2. What are the effects and value of additional functionalities?
 - (a) The interaction between story symbols
 - (b) The attachable animated symbol skills
 - (c) The documentation and play back functionality
3. Did the user experience and the interaction design work out and were perceived as intended?
4. Has the whole Story Table concept a positive effect towards the enhancement in creativity?

6.2.2 Evaluation Methods

Next to the results of our observation during the Story Table session we needed some comparable measurements to base our final assessment of the application on. On this reason we thought of the four following evaluation methods covering following three different aspects:

1. Differences in the Told Stories

We recorded two story telling sessions with the Story Cubes and also with the Story Table. Later, the experiments were analyzed based on the following criteria:

- (a) Taken time per story symbol to come up and tell the story fragment.
- (b) The amount of used words per symbol.
- (c) A ratio of words per second to have a compare value.
- (d) The complexity of the story fragment categorized in the following levels:
 - i. 1 - Only mention and connect the given story symbol to the previous elements.
 - ii. 2 - Adding details or extensions to the story that match the story symbol.
 - iii. 3 - Adding details or extension to the story unrelated to the given story symbol.
- (e) Total time duration of the story telling.
- (f) Total amounts of words for the whole story connected to the story symbols.
- (g) Words per second ratio for the whole story.
- (h) Average complexity of the story fragments.

We use the words per second ratio and the complexity of the store to compare the outcome generated with the Story Cubes with the one generated with the Story Table. A higher words per second ratio and complexity would indicate that the Story Table has a positive effect towards creativity enhancement.

2. Differences in Divergent Thinking and Ideation after the Story Telling Sessions

For an indication on the influence on creativity we came up with the two following test procedures which were executed after the Story Cubes and the Story Table sessions:

(a) *Divergent Thinking - Variation and Interpretation of One Object*

This test was orientated on the figural Torrance Test of Creative Thinking (TTCT) [Makel and Plucker, 2008, p. 249]. The TTCT is one of the most established testing procedures in the field of creativity studies [Makel and Plucker, 2008, p. 249]. Sadly we discovered it too late to be used for our user evaluation since it needs a longer preparation time and training. Our test is performed as follows:

The children get sheets of paper with multiple copies of the same simple figure on it. This figure just consists out of simple lines. The children should try to interpret and associate these lines with as many things as possible. In figure 14 you can see an example set for one test session. The children first get sheets with the left figure which is easier to interpret and associate and afterwards they get sheets with the right figure whose interpretation is a little bit more challenging.

(b) *Divergent Thinking and Ideation - Combination of Two Objects*

In this test the children collaborate in a group and should come up with as many ideas that includes two very different object (e.g. see figure 15) as possible.

For more examples see appendix section D.2.

3. User Experiences and Perception

For better insight into the perceived user experiences of the interaction design and functionalities of the application we held an interview with one of the children who participated in the evaluation next to our own observations as source.



Figure 14: Simple line figures that were interpreted during the test.



Figure 15: Two different objects that were combined during the test.

6.2.3 Evaluation Session

The evaluation took place on August 5 from 15.00 to 17.30 in the SmartXP, building Zilverling at the University of Twente. Four children in the age of 5-6 years participated in the user evaluation. They will all start school this summer.

The course of the evaluation was planned as follows:

- 15.00 — Reception and Short Introduction
- 15.15 — Story Cube Session (2 rounds)
- 15.30 — Creativity Indication Tests 1
- 16.00 — Story Table Session
- 16.45 — Creativity Indication Tests 2
- 17.15 — Goodbye and Clean Up

We could achieve to roughly stay within this time planning during the evaluation session. Sadly we occurred some problems with the Story Table why we needed more time for the Story Table session. Unfortunately this resulted in a shortage in time for the Creativity Indication Tests afterwards since we had to leave the building latest 17.30. On that reason we could only perform one instead of two tests. We decided to choose the test described in point 2b in section 6.2.2 since it is elaborated within the group setting as well as it turned out to be way faster than the test orientated on the figural TTCT.

The results of those tests, our observations and their interpretation are explained in the section here after.

6.2.4 Answers to the Evaluation Questions

For the analysis of the evaluation session we will stick to the evaluation questions from section 6.2.1. The answers are based on the different results of the evaluation methods, our observations during the evaluation session as well as an interview held with one of the children afterwards (for all details and the told stories see appendix section D.3)

1. **to question 1:** One observation we made and what is also extractable from the tables in section D.3.1 is that the children did not take a recognizable time to come up with the next story fragment when using the Story Table. They immediately started to expand the story as soon as the story symbol appeared. During the Story Cube sessions the children often took a long time before start telling their fragment.

Based on this we assume that the interaction technology used to transfer the Story Cube concept into the Story Table increases the motivation, excitement and willingness to tell a story. This can be seen as an advantage over the actual Story Cube concept.

2. **to questions 2a and 2b:** As in the first documented Story Table session (see appendix section D.3.1) the children often started playing around with the story symbols and the symbol skills. This let them halt the story telling. But different than expected they

continued with the story telling after a little while all by themselves.

Since the playing makes the application more fun to use it can be judged as valuable and same to the functionalities enabling them. Additionally playing is also one way to train and express creativity.

3. **to questions 2c:** The parents of the children in the user evaluation and also the kindergarten teacher from the try out (see section 3.4.2), indicated that they judge a documentation and play back functionality as very worthwhile. We also observed that the children had fun using this feature which was confirmed through the interview with the child later on (see point 7 in appendix section D.3.2).

This feature adds definitely value to the Story Table application and also plays an important role for educational matters and future work as will be shown in section 7.2.

4. **to question 3:** As stated before in section 6.1 interacting via the touch table with the Story Table application was not working as well as desired. As expected, this was perceived as disturbing and affecting the user experience (see points 4a and 6 in appendix section D.3.2). Also the interaction design has its weaknesses especially for interaction with multiple users at the same time. For example, the children did not take turns and so they were interrupting and annoying each other (see observation point 2c). Also the position of the interface elements on the table have made it impossible to operate the application from both sides, which turned out to be desirable since every child wanted to be able to perform all actions. Nevertheless the graphical design seems to be suitable since the functionalities of the application seemed to be clearly understood by the children (see point 3, appendix section D.3.2).

Bottom line here is that the interaction design and hardware for the interaction input have to be rethought and improved although the graphical design is going in the right direction. Which possible improvements could be made in the future is also discussed in section 7.2.

5. **to question 4:** Fortunately the minor interaction problems did not influence the usability of the functionalities of the application to a high extent. Therefore we could record and analyze two with the Story Table generated stories and compare them to the Story Cube ones. Furthermore we could perform some tests that give us an indication of the children's creativity level. The results were as follows:

- (a) **Differences in the Told Stories**

The table in figure 16 shows the registered and calculated values for the different stories. Those values make them comparable to a specific extent. Significant is that the words per second index is with 1.1 and 1.03 on the Story Table clearly higher than 0.56 and 0.62 with the Story Cubes. This is caused by factors like the one describe in point 1 of this list. Also the complexity of the stories with 1.33 and 1.375 are slightly higher using the Story Table in comparison to the Story Cubes with 1.25 for both stories (See section 6.2.2 point 1d for the category key).

- (b) **Differences in Divergent Thinking and Ideation after the Story Telling Sessions**

Since we unfortunately could not executed the "Variation and Interpretation of One Object" test after the Story Table session we only can compare the results of the "Combination of Two Objects" test with each other (see appendix section D.3.3 for the detailed results). This test had an outcome of 9 different statements after the

Story Cube session. Repeating this test with two different objects after the Story Table session lead to an outcome of 13 statements. This can be seen as an indication that the Story Table stimulated the divergent thinking and willingness to collaborate to a higher extent than the Story Cubes. We observed as well that during the second performance of the test not only the level of collaboration was higher, but also the share was more equally distributed over the 4 children.

The experiments performed can be seen as a promising indication that the approach has the intended effect. However, for a scientific proof of concept a series of more extensive tests would be necessary to validate an effect or enhancement on children's creativity, especially on the long term. But reviewing the before mentioned results and observations we are confident that the Story Table has a positive effect towards the enhancement of creativity as extension of the Story Cube concept. Thus we judge it as an valuable application that has the potential for further future work and improvement.

Session	Time in sec*	#Words	Words/sec	Complexity
Story Cubes 1	80	41	0.51	1.25
Story Table 1	29	32	1.1	1.33
Story Cubes 2	61	38	0.62	1.25
Story Table 2	64	66	1.03	1.375

Figure 16: Results of the analysis of the 4 different stories told with the Story Cubes and the Story Table.

7 Conclusion

The evaluation described in the section before concludes this project and enables us to review its course and outcome and also to take a perspective on potential future work in the following sections.

7.1 Review on the Project Course and Outcome

Creativity is a research topic, where its influential factors, composition and variety are investigated. Furthermore the role creativity plays in art, but also in science, engineering and everyday life. The attempt to develop an application for children aimed on the enhancement of their creativity forms a challenging problem.

Building our application on an already existing concept, the Rory's Story Cubes, helped significantly to achieve an worthwhile prototype and valuable results in the scope of this project. Furthermore involving children and kindergarten teachers in the design process from an early stage turned out to be beneficial. On the one hand requirements from children and teachers lead to relevant design decisions in the beginning. On the other hand concepts like the graphical design could be improved based on children's feedback during the further course of the realisation. The design and implementation of the Story Table prototype followed a structured and purposive process of analysing requirements, deriving and specifying functionalities and realising these.

By adding interaction technologies to the Story Cube principle we could create an application that has an positive effect towards the enhancement of creativity as shown in section 6.2.4. The results are encouraging and indicate that the Story Table after undergoing some minor improvements is already an application that is worth to be released to the market. Nevertheless, we think the Story Table concept has still a higher potential. How we would approach to achieve this is described in the next section.

7.2 Future Work

An continuation of this project could be driven on the following aspects:

1. **Interaction Design Improvements** — The interaction design needs improvement in terms of that it should support input of all user at all time to a specific extent but also should ensure that the child(ren) that is busy telling a story fragment is not disturbed or interrupted by a child that already request the next item. The kindergarten teacher form the try out in section 3.4.2 mentioned the well-known concept of a "talking rock" as possible direction for a solution.
2. **Increase the Availability** — Transferring the Story Table application to a platform like the before mentioned SMART Table (see section 3.5) using the provided SDK would instantly make it available to a variety of already existing and would make it more attractive to new potential customers.
3. **Increase the Worth as Content Creation Tool** — Engaging students/kids to actively create content instead of just passively consuming media supports in an early age is supporting their creative development [Hall, 2012, p. 97]. An extension of the functionalities of the Story Table could be thus worthwhile maybe especially with increasing user age. For example two possible new features:

- (a) *Enrich the Story Afterwards* — Adding additional media like own drawings, pictures, sound effects, music or voice over could make the recorded stories more precious to their creators and also indirectly make them reflect on the them [Resnick et al., 2005, p. 12].
- (b) *Enable Content Sharing* — But all these enrichments are not as useful if there is no possibility to share the story with others [Resnick et al., 2005, p. 5]. This could be realized via social media or a own online platform. Giving the children the possibility to exchange their stories and show it to important people like their parents. Enabling this feature through or with supervision could be worthwhile to keep the amount of functionalities available to the children low, especially for young children.

References

- Amy Bruckman and Alisa Bandlow. *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*, page 39. Lawrence Erlbaum and Associates, 2002.
- Alessandro Cappelletti, Giulia Gelmini, Fabio Pianesi, Franca Rossi, and Massimo Zancanaro. Enforcing cooperative storytelling: First studies. *Proceedings of the IEEE International Conference on Advanced Learning Technologies*, 9:5, September 2004.
- François Decortis, Elisa Rubegni, Anne Bationo Tillon, and Edith Ackermann. Interactive technologies that enhance children’s creativity. *Interaction Design and Children 2013*, page 4, June 2013.
- Tony Hall. Digital renaissance:the creative potential of narrative technology in education. *Creative Education*, 3(1):pp 96–100, February 2012.
- Gleen E. Krasner and Stephen T. Pope. Cookbook for using the model-view-controller user interface paradigm in smalltalk-80. *Journal of Object-Oriented Programming (JOOP)*, pages 26–49, August/September 1988.
- Matthe C. Makel and Jonathan A. Plucker. *Handbook of Giftedness in Children - Chapter 13*, pages pp. 247–270. Springer, 2008.
- Mitchel Resnick, Brad Myers, Kumiyo Nakakoji, Ben Shneiderman, Randy Pausch, Ted Selker, and Mike Eisenberg. Design principles for tools to support creative thinking. *Research Showcase*, page 16, October 2005.
- Tim Warnecke, Patrick Dohrmann, Alke Jürgens, Andreas Rausch, and Niels Pinkwart. *Cooperative Design, Visualization, and Engineering Volume - Collaborative Learning through Cooperative Design Using a Mutlitouch Table*, volume 6874 of *Lecture Notes in Computer Science*, pages pp 22–29. Springer, 2011.

A Try-out Documentation

Try-out Setting

- Children Day Care - DRK Kinderwelt Borken - Burlo, Germany
- "Regenbogen" nursery group - already experienced with the story cubes and similar concepts
- Date: 08-05-2013 Starting time: 9 am
- Try-outs with at least two groups
- Groups with a size of 4-6 children that are within the age of the target group (4-6)
- Concluding a talk/interview with the nursery teacher

Points of Interests

Points of discussion from the concept:

1. Which game mode? Support soft- and/or hard-liner?
 - (a) Soft-liner: Providing new objects continuously over the process.
 - (b) Hard-liner: Provide all objects already in the beginning to give the opportunity to plan the story
2. Drawing as active participation of the the kids in documenting the story enhancing the creative thinking process?
3. Is drawing of story elements grabbing the focus from the actual story generating process (too much)?
4. Personal protagonist
 - (a) Super-self vs. existing protagonist
 - (b) Drawing vs. composition

Questions for the Interview with the Nursery Teacher:

- How have you used the story cubes in the past?
- What were the reactions of the children?
- What are your experiences from playing together with the children with the story cubes?
- Do you try to enhance children's creativity by specific methods? If yes, what are those methods?
- What are a good set up for children to collaborate within a group?
- Do you use technology for parenting and/or entertaining the children?

- If yes, do you use technologies specially developed to be used by children in kindergarten/primary school age?
- Do you think recording/storing the generated stories has a added value? Have you done something equivalent in the past?

Planned course

1. Informational talk - Planning
2. Observation of nursey teacher playing with the story cubes together with the children. (15-30 min)
3. Try-out of the paper user interface mock ups (also using the story cubes) with one drawing colour. (30 min)
4. (Optional) Playing with the story cubes? (maybe skip this to shorten the needed time)
5. Task for the children: Draw/create your own hero/super-self? (30 min)
6. Try-out of the paper user interface mock ups (also using the story cubes) with several drawing colours. (30 min)
7. Extend the experiment introducing a hero? Ask the children whether they want to play with their own hero or an existing one from a famous story book. (30 min)
8. (Optional) Play together with the children with the iPad. (30 min)
9. First with a simple drawing app (also offering a stylus to operate the iPad)
10. Second with draw a stick man
11. Final talk with nursery teacher

Preparations

- Buy a drawing block in A3
- Prepare small carton sheets to draw the story symbols on
- Prepare A5 carton sheets for the heroes
- Prepare body party for assembling heroes

Actual course

- Short introduction talk with the kindergarten teacher. (But not mentioning details of the final concept)
- 1. Try-out: Story Cubes with around 5 year old children. In the second round with additional documentation of the story through drawing the interpretation of the symbols down on carton cards.

- 2. Try-out: Playing with the story Cubes with around 4 years old children
- 3. Try-out: Playing with the story Cubes with around 5-6 years old children (who will start primary school in summer)
- Interview with kindergarten teacher (Introduction to the actual concept, several questions)

Interesting Results & Conclusions

See section Points of Interests for the matching questions.

- to 1.1: Soft liner
- to 1.2: Only Random - keep the application simple with less functionality - children need repetition for learning.
- to 2.1: Maybe in general - but in this application it is distracting from the actual task
- to 2.2: As expected several drawing colours distract the children even more and take them far away from the story telling process.
- to 2.3: Yes definitely.
- to 3: Is clearly limiting the creative process. It directs the story already in one specific direction.
- to 3.1: No clear result here, but it seems that more children would prefer a nice drawn protagonist. The nursery teacher agreed in this point.
- to 3.2: Not handled.

Additional points:

- Where to place the microphone? Place it in a talking rock“? This could also handle whose turn it is.
- Beginning and end of the story seems to be difficult to make up.
- No technical devices except a cd-player in this kindergarten. Nursery teacher told us that in a kindergarten in which she worked previously they had a common PC with some language learning software on it.
- Nursery teacher approves that’s a table is a good set up for children to collaborate in a group of 4-6.
- Nursery teacher told that many nursery teachers are critical when it comes to the use of technology/computers in an early age.
- But she admits that it is getting important to get children involved with technology and is positive about the use of tailor made, not traditional PC like hardware and suitable software.
- She thinks that recording those stories (in picture and audio) is very worthwhile and would make the application add some more value to the actual game.

B Realisation Documentation

B.1 Programming documentation

B.1.1 Software Architecture

Class specification

- ***storyTable class***

Class instances owned:

- Multiple instances of the different *view* subclasses
- A *allSymbols* vector of *objectInfo* structures containing all available story symbols
- A *interactions* vector containing all by the current view class detected interactions
- The *tuioClient* (an *ofxTuio* instance)
- The *screenRecorder* (an *ofxQTKitAVScreenRecorder* instance) to record the stories
- The *storyPlayer* (an *ofVideoPlayer* instance) to load and play back the video files of the stories
- Multiple *ofSoundPlayer* instances to give different audio feedback on the various interactions for the triggered functionalities

Methods:

- *setup()*, *update()* and *draw()* — standard in openFrameworks to execute the application.
- *switchView()* — to switch between the different menus.
- *startNewStory()* — creates a new *storyModel* object and gives it a random set of story symbols, switches to the Story Mode Menu and starts the screen recording.
- *getNextStorySymbol()* — gets the next story symbol from the current *storyModel* object and demands the *storyModeView* instance to add a new *uiElementSymbol* as representation of the story symbol to it.
- *addSkillToSymbol()* — attaches the chosen symbol skill to the selected story symbol.
- *closeThisStory()* — demands the finalization of the screen recording, saves the file path and a screenshot for the representation of the story in the current *storyModel* object and demands the *mainMenuView* instance to add a new *uiElementButton* as representation of the story to it.
- *playBackStory()* — gets the video file path of the story with the storyID that was given to him, gives this file path to *storyPlayer* which loads the video and then switches to the Story Player Menu.
- *handleInteraction()* handles the response to all interaction events present in the *interactions* vector.
- *analyzeInteraction()* — analyzes on which kind of *uiElement* instance the interaction happened according to the ID saved in the *interaction* structure given.
- *symbolInteraction()* — recognizes all defined interaction behavior and performs the according defined responses for *uiElementSymbol* instances.

- *buttonInteraction()* — recognizes all defined interaction behavior for *uiElementButton* instances and provokes the performance of the represented functionality.
- *pressButton()* — performs the defined actions and gives audio feedback according to the ID of the *uiElementButton*.

Initially Planned Software Architecture

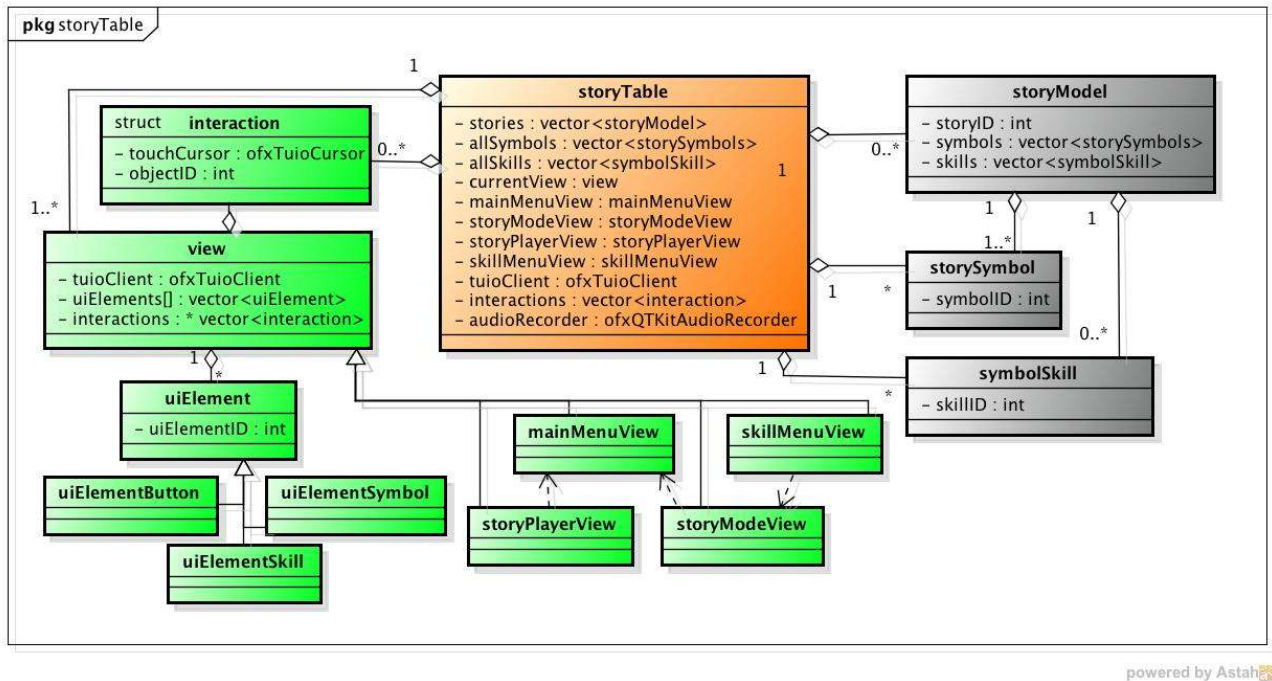


Figure 17: Initially planned software architecture according to the MVC principle.

B.1.2 ID Index

```
//DEFINITION viewIDs
#define MAINMENU 'A'
#define STORYMODEMENU 'B'
#define SKILLMENU 'C'
#define STORYPLAYERMENU 'D'

//DEFINITION storySymbol category aliases
#define NATURE 'G'
#define EVERYDAYLIFE 'H'
#define WORKLIFE 'I'
#define HUMAN 'J'

//DEFINITION storySymbol sizes
#define SMALL 1
#define MEDIUM 2
#define LARGE 3
```

```
//DEFINITION buttonIDs
#define CREATENEWSTORY 1
#define ADDSTORYSYMBOL 2
#define ENTERSKILLMENU 3
#define BACKTOSTORYMODE 4
#define FINISHSTORY 5
#define PLAYSTORY 6
#define PAUSESTORY 7
#define RESTARTSTORY 8
#define QUITSTORYPLAYBACK 9
#define ATTACHFIRESKILL 10
#define ATTACHWATERSKILL 11

#define MINSKILLBUTTONINDEX 10

//DEFINITION storyIDs
#define MINSTORYINDEX 50
#define MAXSTORYINDEX 99

//DEFINITION storySymbolIDs
#define MINSYMBOLINDEX 100
#define MAXSYMBOLINDEX 299

//DEFINITION storySkillIDs
#define MINSKILLINDEX 300
#define THROWFIRE 300
#define THROWWATER 301
#define MAXSKILLINDEX 399
```

B.2 The GUI Design

B.2.1 Initial Design from External Illustrator

Before we decided to go with the GUI design in another direction we had hired freelancer Marvin Majewski, an external illustrator. We gave him some concept sketches to orientate on. In some Skype meetings we agreed on a children's book like design. Here two screenshots of the GUI created using his graphics:

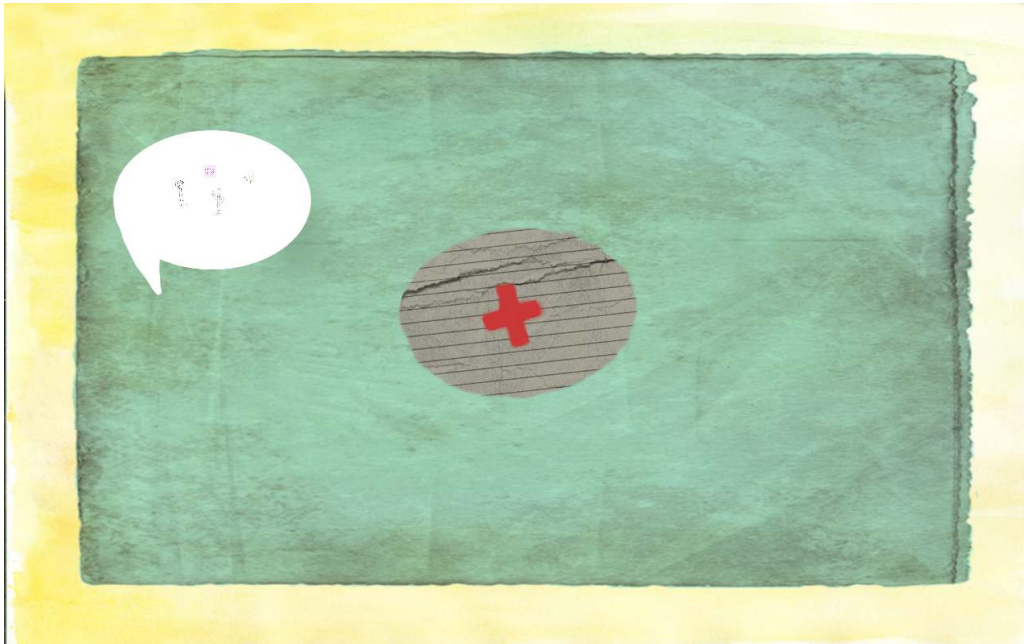


Figure 18: Main menu in children's book style

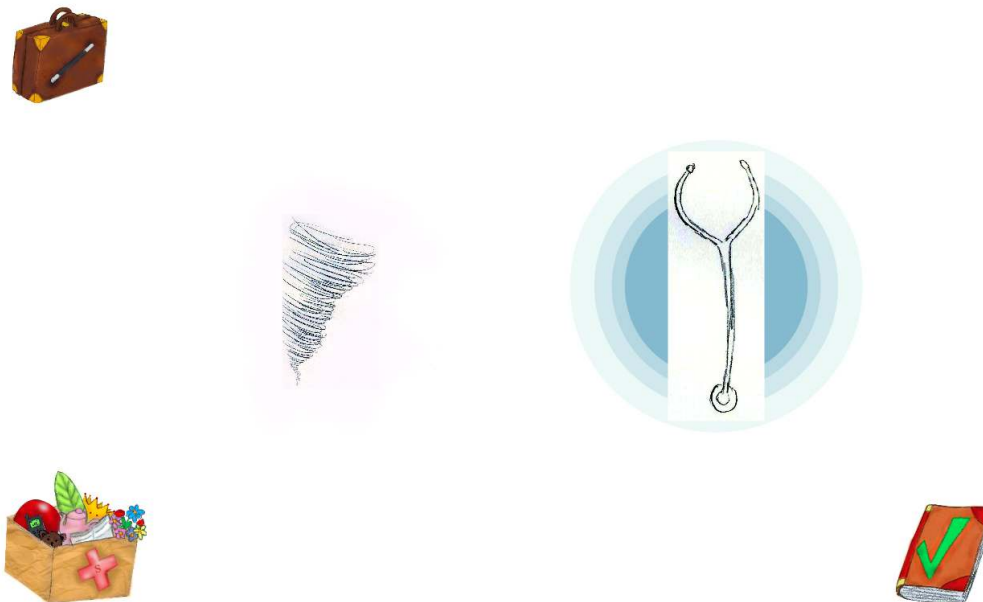


Figure 19: Story Mode menu in children's book style

B.2.2 The Color Scheme

For a picture of the color scheme see figure 8. Here a list with the RGB values of the colors:

- Black - 0 | 0 | 0
- Grey - 120 | 120 | 120
- White - 255 | 255 | 255
- October - 255 | 114 | 0
- Super Pink - 255 | 0 | 221
- Electric Green - 1 | 255 | 35
- Banana Yellow - 253 | 255 | 1

B.2.3 The Icon Sets

The graphics within the Story Table applications were mainly taken from or based on following icon sets:



MONICONS - 1 - BY TIM BOELAARS

[HTTP://STORE.TIMBOELAARS.NL](http://store.timboelaars.nl)

Figure 20: Monicons 1 — by Tim Boelaars



Figure 21: othercircles — by Lubos Volkov

C The Prototype

In the following several screen shots of the different menus of the Story Table application in their different states:

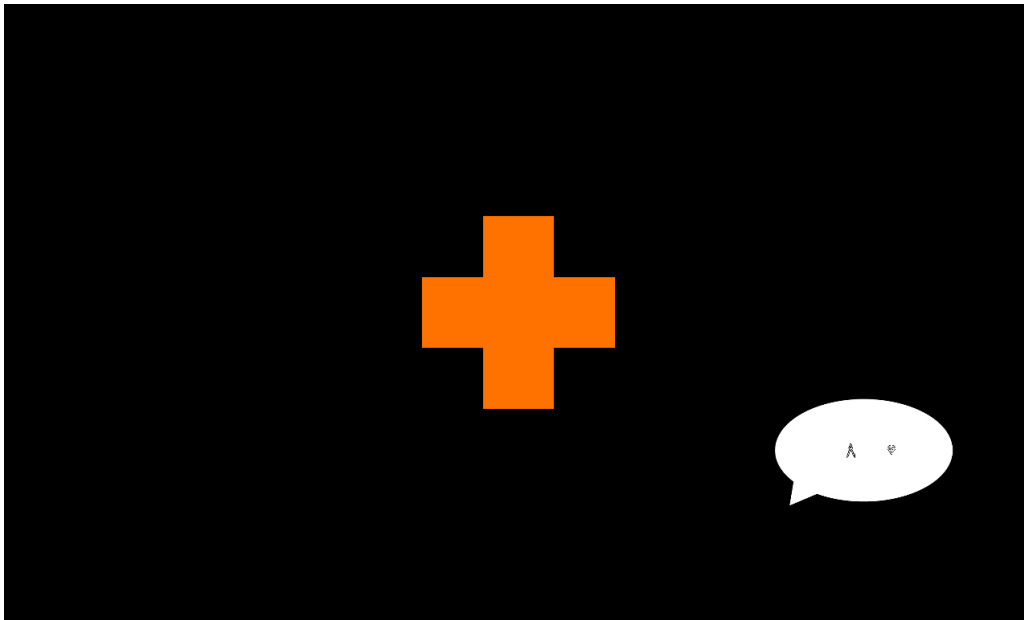


Figure 22: Main Menu — the orange plus is the button to start a new story - the speech bubble is one representation of previous created story.

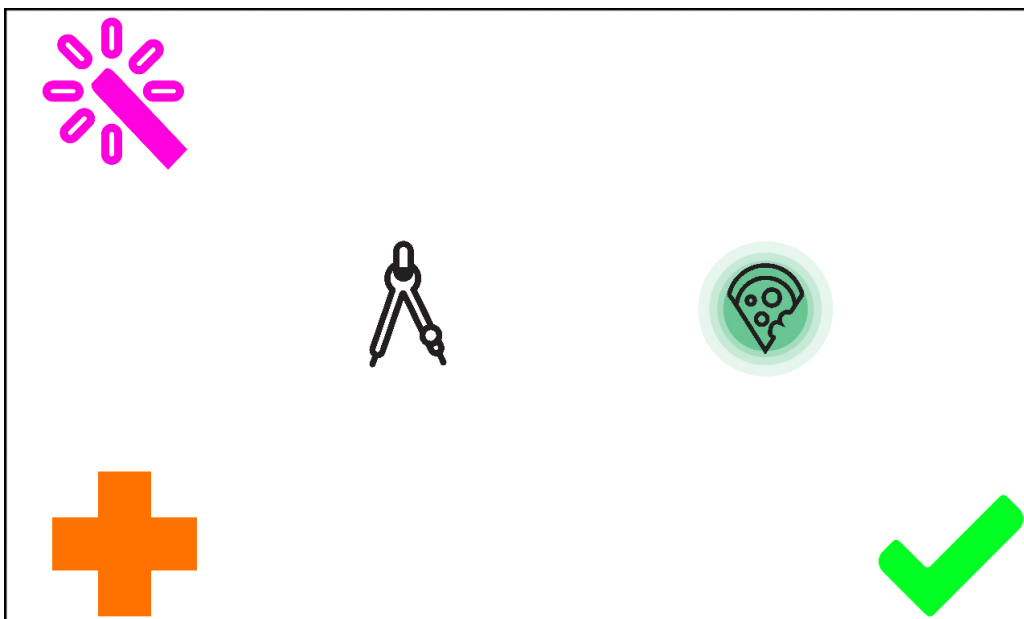


Figure 23: Story Mode Menu — the smaller orange plus is the button to get the next story symbols (it is deactivated after one was requested (it turns grey) and it disappears if all available story symbols are on the screen)) - The green tick is the button to finish the story - If one story symbol selected the pink magic stick appears which is the button to enter the Skill Selection Menu to attach a symbol skill to the selected symbol.

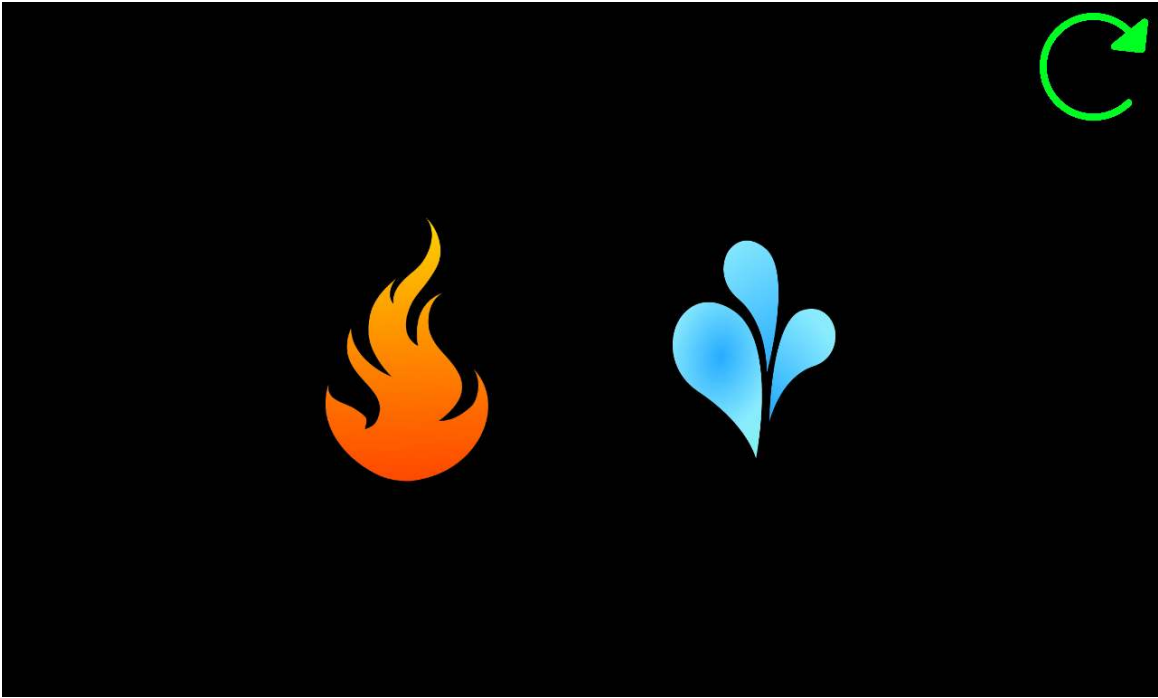


Figure 24: Skill Selection Menu — Touching a symbol skill representation provokes the application to attach the skill to the previous select symbol and return back to the Story Mode Menu - The green arrow is the button to return back to the Story Mode menu without attaching a skill.

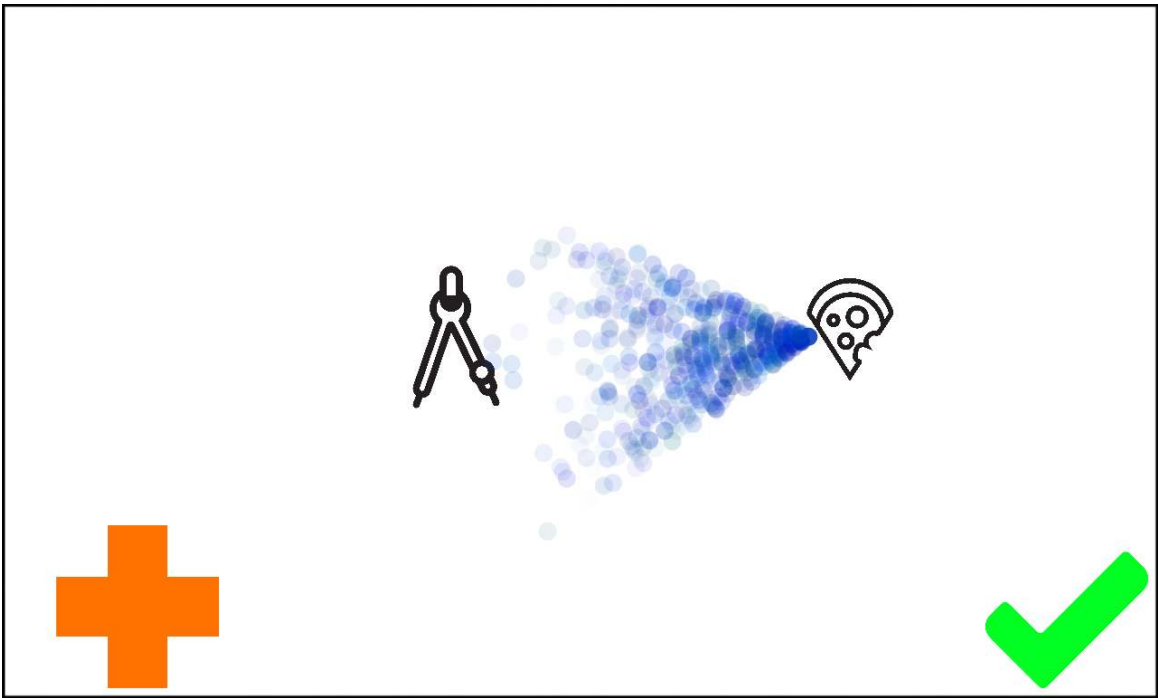


Figure 25: Story Mode Menu — Here the *water throwing* skill is attached to the story symbol.

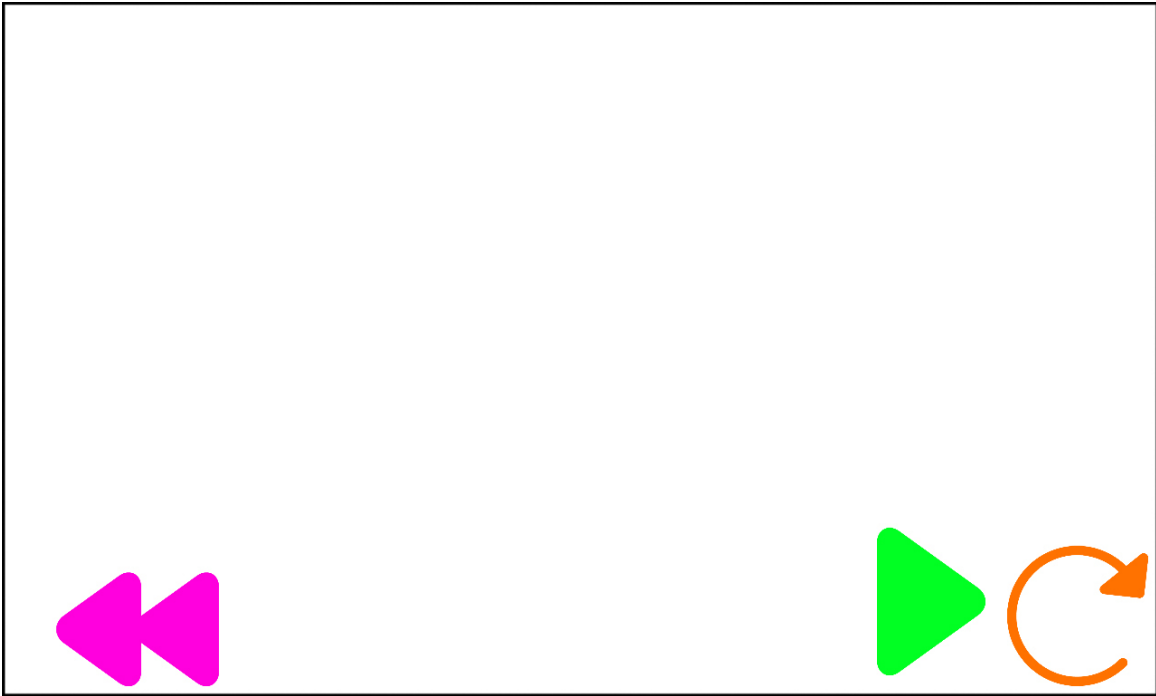


Figure 26: Story Player Menu — Shown are the buttons present if the story play back is stopped.

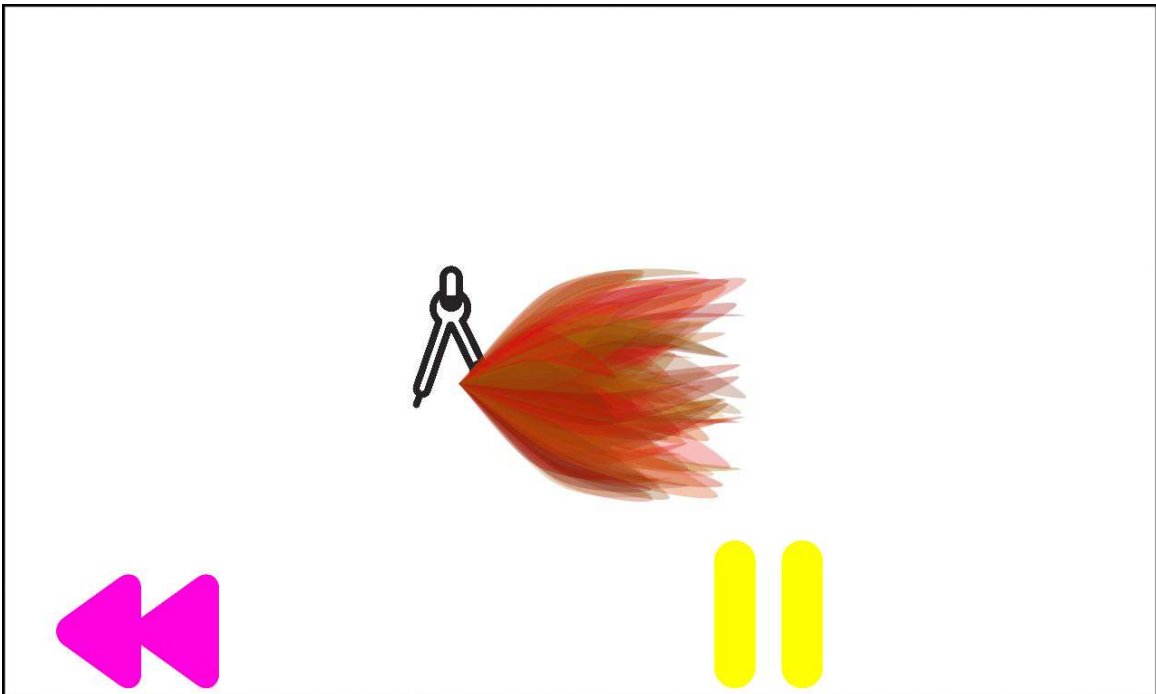


Figure 27: Story Player Menu — Shown are the buttons present if the story is played back.

D User Evaluation Documentation

D.1 Legal Agreement

Borken, den 29.07.2013

An die Erziehungsberechtigten des Kindes

Ausflug zur Universität Twente und Ausprobieren des Geschichten-Erzähl-Tisches

Sehr geehrte Eltern,

der Student Tobias Uebbing hat im Rahmen seiner Abschlussarbeit für seinen Bachelor das Konzept und den Prototypen eines „Story Tables“ entwickelt. Ziel des Tisches ist es spielerisch die Kreativität der Kinder zu fördern.

Grundprinzip des Tisches ist, dass die Kindern nach und nach zufällige Symbole bekommen, die sie in ihren Geschichten einbauen sollen. Diese Symbole zeigen z.B. ein Zelt, eine Blume, ein Auto, ein Stück Pizza usw. Den Symbolen können auch noch verschiedene Eigenschaften hinzugefügt werden (im Prototyp bisher Wasser und Feuer spucken). Diese Eigenschaften werden dann für eine kurze Dauer animiert wiedergegeben. Der ganze Erzählvorgang (das was auf dem Tisch passiert und dargestellt und zusätzlich das was um den Tisch herum gesprochen wird), spricht die Geschichte der Kinder, wird vom Tisch aufgezeichnet und kann dann später auf dem Tisch wieder angeschaut werden.

Der Auftrag der Abschlussarbeit beinhaltet auch das oben beschriebene Spiel zu testen, um die Gültigkeit des Konzeptes nachweisen zu können. Dazu sind Kinder im Alter von 4-8 Jahren nötig.

Eine Teilnahme ihres Kindes würde folgende Zustimmungen ihrerseits erfordern:

1. Ihr Kind darf mit Jasmin Uebbing mit dem Auto zur Universität Twente in Enschede, den Niederlanden, fahren und dort an einer Spielrunde mit dem „Story Table“ teilnehmen.
2. Ihr Kind darf für wissenschaftliche Zwecke bei dieser Spielrunde aufgezeichnet werden. Diese Videos dienen der späteren Auswertung und (internen) Demonstration/Präsentation.
3. Diese Videos werden zu Demonstrationszwecken auch öffentlich (online) zugänglich gemacht (z.B. auf dem Portfolio System des Creative Technology Studienganges: <http://creators.ewi.utwente.nl>). Wenn sie damit nicht einverstanden sind, dürfen sie uns ohne Angabe von Gründen jederzeit dazu auffordern dieses zu Unterlassen und mögliche bereits bestehende online verfügbare Kopien zu löschen. Dies werden wir allezeit respektieren.

Die Spielrunde wird am Montag dem 05.07. nachmittags zwischen 15 und 17 Uhr an der Universität Twente im Gebäude Zilverling, Raum A124 stattfinden. Die Kinder werden Burlo somit gegen 14 Uhr verlassen und gegen 18 Uhr wieder erreichen. Über genaue Zeiten und eventuelle Änderungen werden Sie zeitnah informiert.

Für ihre Erlaubnis und die Teilnahme ihres Kindes wären wir Ihnen sehr dankbar.

Mit freundlichen Grüßen,

Tobias Uebbing &
Angelika Mader (Projektbegleiter)

PS: Für Rückfragen können sie sich jederzeit an Tobias Uebbing wenden (Mobil: +491713129193)

(Nicht Zutreffendes bitte streichen.)

Hiermit bestätige(n) ich / wir, dass unser Kind _____
(Name des Kindes)

an dem Ausflug zur Universität Twente am 05.07.2013 teilnehmen darf und, dass wir allen drei / den ersten

beiden oben beschriebenen Punkten zustimmen. _____
(Unterschrift des/der Erziehungsberechtigten)

Figure 28: Form for the Legal Agreement with the legal guardian of the children participating in the user evaluation to clarify the course of the evaluation and get the accordance to make video recordings and use these recordings for evaluation, presentation and demonstration purposes.

D.2 Evaluation Methods

D.2.1 Divergent Thinking - Variation and Interpretation of One Object

Test on divergent thinking inspired by the figural Torrance Test of Creative Thinking. For further explanation see section 6.2.2.

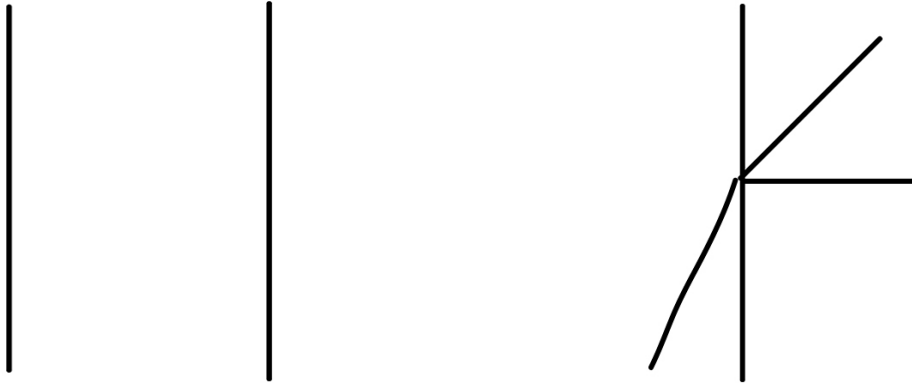


Figure 29: Two fingers consisting of simple lines, to generate a wide space for interpretation. The right one has a slightly higher complexity than the left one and should lead to interpretations with a higher complexity.



Figure 30: Second set of line figures for interpretational tests.

D.2.2 Divergent Thinking and Ideation - Combination of Two Objects

Test on the ability to generate associations and combinations of two objects from different domains. For further explanation see section 6.2.2.



Figure 31: Two objects from different domains that needs to be combined or brought together into one context during the test session.

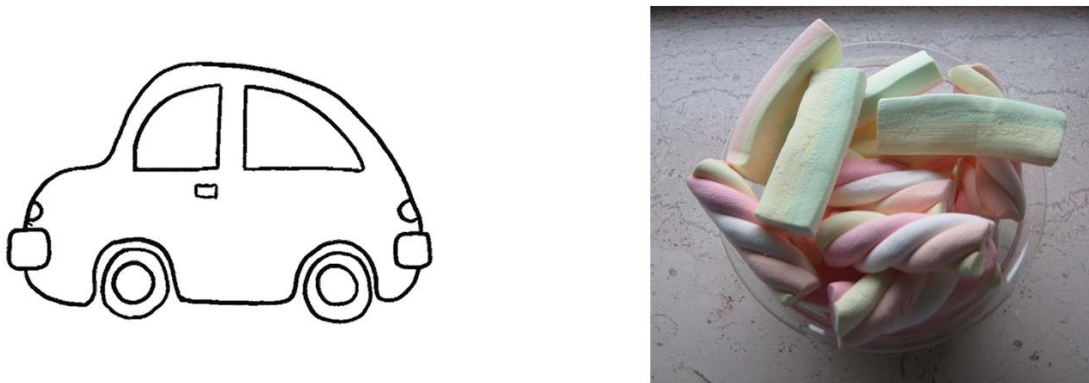


Figure 32: Second set of objects that should be combined.

D.3 Evaluation Results

D.3.1 The Story Telling Sessions

The Story Cubes

Session 1:

The story:

1. **From us:** *"Es war einmal ein Indianer, der hat eine Schatzkarte gefunden. Auf der Schatzkarte war ein Pfeil. Dieser zeigte in die Richtung eines Berges ..."*
2. **Symbol: Apple** → *"... hat er einen Apfel eingepackt ..."*
3. **Symbol: Fountain** → *"... und dann kam der Indianer mit seinem Apfel zum Brunnen und sagte: "Oh, ein Brunnen, da wasch ich glatt mal meinen Apfel."*
4. **Symbol: Padlock** → *"... und dann hat er ein Schloss gesehen."*
5. **Symbol: Gate latch** → *"... und das Schloss war in einem Riegel"*
6. **From us:** *"... und dann kam er einfach nicht mehr weiter. Enttäuscht ging der kleine Indianer wieder zurück und aß seinen Apfel."*
7. *One child wanted to continue the story and searched for a key on the cubes to help the native american to open the lock.*

Symbol	Time in sec*	#Words	Words/sec	Complexity	Child
Apple	(17) 20	5	0.25	1	1
Fountain	(13) 20	22	1.1	2	2
Padlock	4	7	1.75	1	3
Gate latch	(7) 20	7	0.35	1	4
Story	80	41	0.51	1.25	

Figure 33: Measurements on the story generated in the first story telling session with the story cubes. (Times in brackets are the time the children took to think before start telling the next part of the story.)

Session 2:

The story:

1. **Symbol: Sleeping** → *"Es war einmal ein Junge der hat geschlafen und dabei geschnarcht."*
2. **Symbol: Marbles** → *"Und dann hat der Junge gespielt mit Perlen."*
3. **Symbol: Loupe** → *"Dann hat das schlafende Kind nach einer Murmel mit einer Lupe gesucht."*

4. **Symbol: Rainbow** → "Und dann hat er einen Regenbogen gesehen."

Symbol	Time in sec*	#Words	Words/sec	Complexity	Child
Sleeping	(10) 17	11	0.64	2	4
Marbles	(3)12	8	0.67	1	3
Loupe	(2) 10	12	1.2	1	2
Rainbow	5	7	1.4	1	1
Story	61	38	0.62	1.25	

Figure 34: Measurements on the story generated in the second story telling session with the story cubes. (Times in brackets are the time the children took to think before start telling the next part of the story.)

The Story Table

Session 1:

The story:

1. **Symbol: Chair** → "Es war einmal ein Stuhl [wie gerade eben] und darauf setzte sich eine schöne Prinzessin."
2. **Symbol: Water Hose** → "Und dann hat sie einen Wasserschlauch gefunden als sie wieder aufstand."
3. **Symbol: Boat** → *Here the children started playing around with the boat and the water skill. One child made an addition to the story in-between and said "The chair is now falling down" effected by the water. And surprisingly after some seconds the children focused again on continuing telling a story with the new symbol.*
4. **Symbol: Headphones** → "Den Kopfhörer setzte die Prinzessin auf."
5. *In the end the children continuing playing with the attachable symbol skills and also a discussion arose whether the boat is allowed to throw fire and not only water.*

Symbol	Time in sec*	#Words	Words/sec	Complexity	
Chair	10	15	1.5	1	
Water hose	10	11	1.1	2	
Boat	-	-	-	(3)	
Headphones	7	6	0.85	1	
Story	52	32	0.61	1.33	
- Play time	29	32	1.1	1.33	

Figure 35: Measurements on the story generated in the first story telling session with the story table.

Session 2:

The story:

1. **Symbol: Robot** → "Es war einmal ein Roboter der wollte in den Park gehen."
2. **Symbol: Pencil & Ruler** → "Der wollte lieber malen im Park."
3. **Symbol: Heart** → "Dann hat er ein anderes Robomädchen gefunden und hat sich in sie verliebt"
Another child suggested another option:
 "Er hat mit den Buntstiften ein Herz gemalt."
4. **Symbol: Sewing Machine (it is actual a microscope)** → "... und dann hat er genäht, ein Stoffherzchen hat er genäht."
5. **Symbol: Trees** → "Dann hat er Tannenzweige und Bäume gefunden."
Again another child had another suggestion:
 "Der hat dann ne Decke mit nem Wald drauf genäht."
6. **Symbol: House** → "Dann hat er ein Haus gebaut, darin wohnt er."
7. **Ending** → "Und dann ging er nach Hause. Tschüss!"

Symbol	Time in sec*	#Words	Words/sec	Complexity
Robot	5	11	2.2	1
Pen & ruler	13	6	2.0	1
Heart	8	13	0.61	3
	8	5	1.6	1
Sewing Machine	10	7	1.43	2
Trees	7	7	1.0	1
	5	10	2.0	1
House	4	7	1.75	1
Story	64	66	1.03	1.375

Figure 36: Measurements on the story generated in the first story telling session with the story cubes.

Observation during the Story Table Session:

1. After the short introduction to the multitouch table in general and the Story Table application the interest of the children was more into exploring the functionality of the table for the first 15 minutes.
2. The story telling functionalities:
 - (a) The children involve previous story symbols into their story to a higher extend than during the sessions with the Story Cubes.
 - (b) They seem to be more actively involved in comparison to the story symbols. Even group discussion, collaboration and contributions arise as intended as in Session 2 with the Story Table.
 - (c) But there are also interrupting and annoying each other. (Pressing the button to get a new story symbol or want to attach another skill to the symbol another child is playing with.)

- (d) The animation work as intended and seem to to be very attractive to the children. Nevertheless they could be still too distracting from the story telling. However in the Story Table Session 1 above it worked out quite well.
- (e) Some children show a preference for the generation of the story and some are more interested in the play back of the story.
- (f) Consequently those children are into replaying the story recording over and over again.
- (g) Nevertheless they are not always paying their complete attention to what they told before rather to the fact that it is funny that they are hearing themselves.

3. The interaction design:

- (a) Children tend to lay the whole arm on the table to reach out for items. This results in not accurate interaction points, since the center point of the arm is used for the interaction then.
- (b) The application should be completely operatable from all (both) sides of the table. But how to implement this without using too much space on the screen? During the user evaluation the children always went around the table to operate the application. This became especially clear in the Story Player Menu where all operational interface elements are placed on one side of the table.
- (c) They children also still try to interact with the story symbols within the story play back. The interface icons of the Story Mode Menu were already removed from the screen recording on that reason. But how to mediate the fact that it is an recording and an interaction is not possible anymore?
- (d) The deactivation of the button to get a new story symbol was immediately clear and was accepted as given fact as well that it disappears if aloe symbols are on the screen.

D.3.2 Interview with One Child

The following interview was held with one of the four children 13 days after the evaluation session:

1. How do you like to play with the touch table? Was it fun?

Yes it was fun. I liked to play that with the fireflies and where you tell stories.

2. You do not like to play with the colour fluids?

Sure!

3. Was it clear what you can do within the story table application?

Yes!

- (a) **E.g. that the big plus in the main menu stands for starting or adding a new story?**

Yes!

4. What can you do during the story telling?

You can move the story symbols around on the table.

(a) Does that work well?

Not that well, that could be better.

5. What else can you do with the story symbols?

Move them.

Indeed, but what happened if you touched one for a longer while?

Then you could make the symbol spit fire or water. Like with the boat. We made it spit fire one and spit water another time.

(a) Do you like this feature?

Yes.

(b) Was it fun to play around with it?

Yes.

6. The Story Table is equal to the Story Cubes, isn't it?

Yes, but you do not know which symbols are coming on the Story Table. And the table is not operating that well.

7. How do you like it to play back the recorded story afterwards?

I like it very much, I always said to the others: "Come on, let's watch our story."

8. Do you have a suggestion that would make the Story Table even more enjoyable?

I would like to do something with a fairy.

(a) So you would for example like to see some fairytale themed story symbols?

Yes.

9. Something else you liked about the visit?

It was great that in the end also our parents could take a look at the table and the story telling.

D.3.3 Tests to Indicated Level of Creativity

Combination of Two Objects

After Story Cube - Session:

Following combinations and associations were the result of a group brainstorm on the two objects in figure 31:

1. "Der Hammer haut auf die Gummibärchen."
2. "Die Gummibärchen klettern auf den Hammer."
3. "Die Gummibärchen fallen von dem Hammer runter."
4. "Die Gummibärchen und Hammer bauen zusammen ein Haus."
5. "Der Hammer macht Saft aus den Gummibärchen."
6. "Die Gummibärchen fliegen auf dem Hammer davon."
7. "Die Gummibärchen und der Hammer machen einen Wettkampf um das Haus."
8. "Die Gummibärchen machen aus dem Hammer eine Sonnenbrille."
9. "Die Gummibärchen mache aus dem Hammer Plätzchen."

After Story Table - Session:

The brainstorm was repeated on the two objects in figure 32:

1. "Das Auto fährt über den Mäusespeck."
2. "Der Mäusespeck fährt das Auto."
3. "Das Auto möchte mit dem Mäusespeck zur Tankstelle fahren."
4. "Der Mäusespeck und das Auto feiern eine Party zusammen."
5. "Der Mäusespeck und das Auto haben sich kaputt gelacht."
6. "Das Auto und der Mäusespeck gehen zum Kindergarten und dort fahren sie zusammen Auto."
7. "Das Auto und der Mäusespeck essen Pommer zusammen."
8. "Der Mäusespeck hat das Auto zum Pizza essen eingeladen."
9. "Das Auto und der Mäusespeck essen zusammen Äpfel."
10. "Das Auto isst den Mäusespeck."
11. "Das Auto und der Mäusespeck gehen zusammen an den Strand."
12. "Das Auto und der Mäusespeck gehen mir ihrer Tochter in den Zoo."
13. "Das Auto und der Mäusespeck nehmen Sonnenbrillen mit zum Strand."

Variation and Interpretation of One Object

After Story Cube - Session:

Simple Figur (see left one in figure 29):

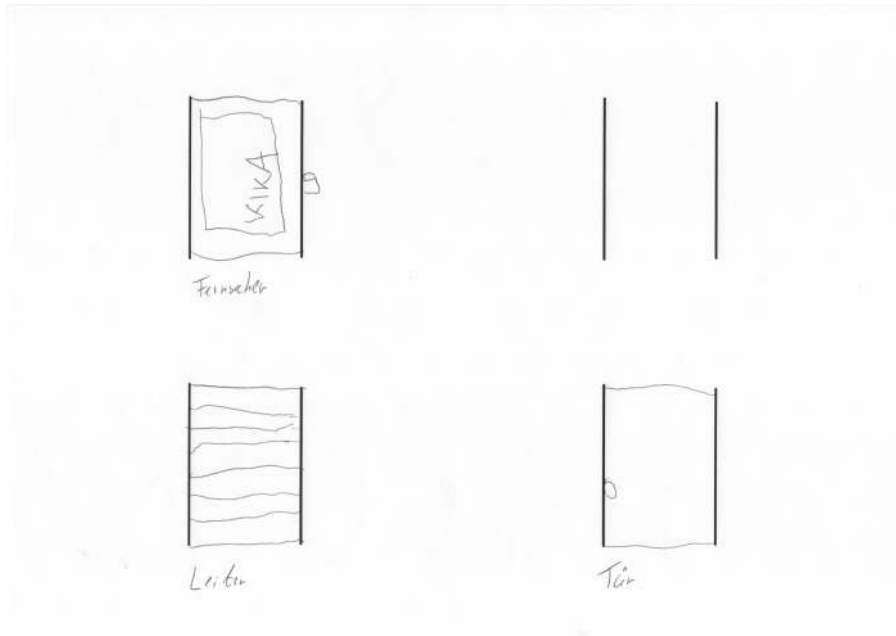


Figure 37: Sheet 1.1 - 3 unique interpretations in total

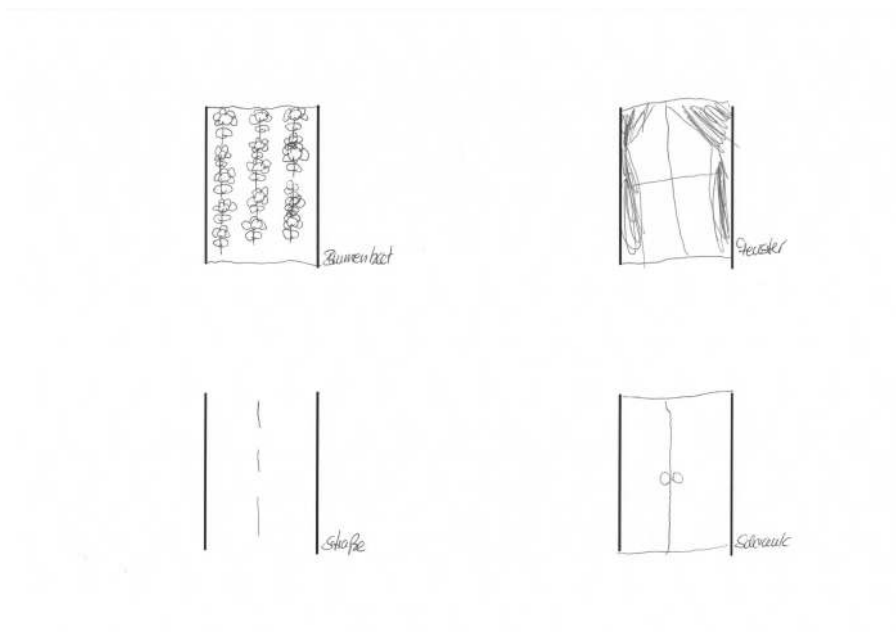


Figure 38: Sheet 1.2 - 7 unique interpretations in total

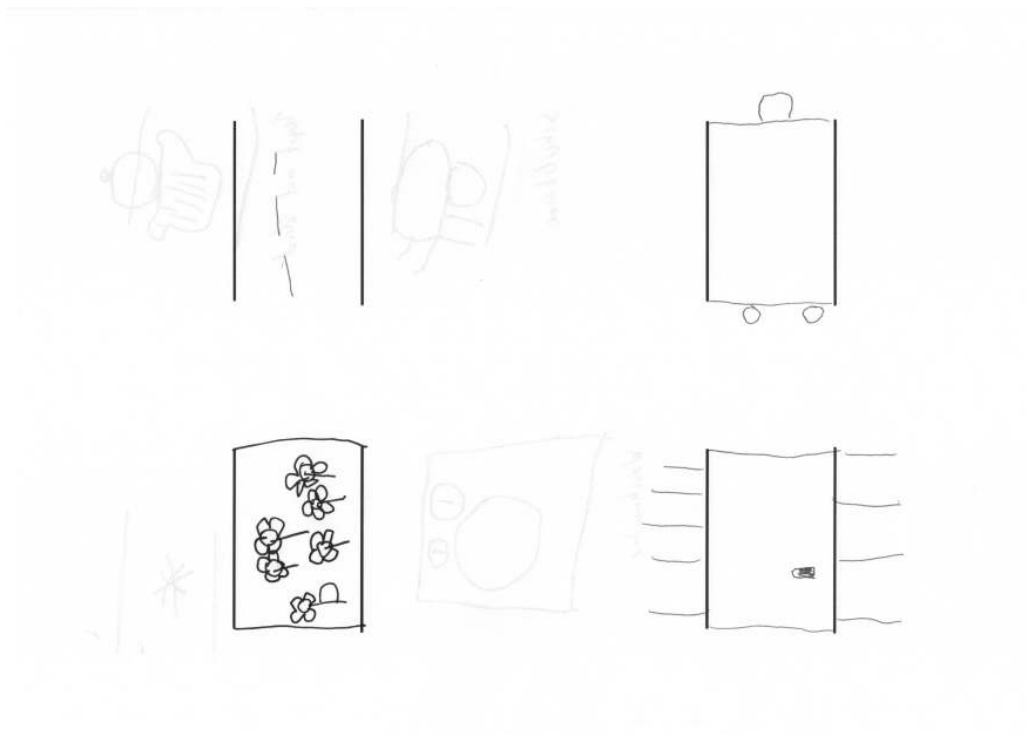


Figure 39: Sheet 1.3 - 10 unique Interpretations in total

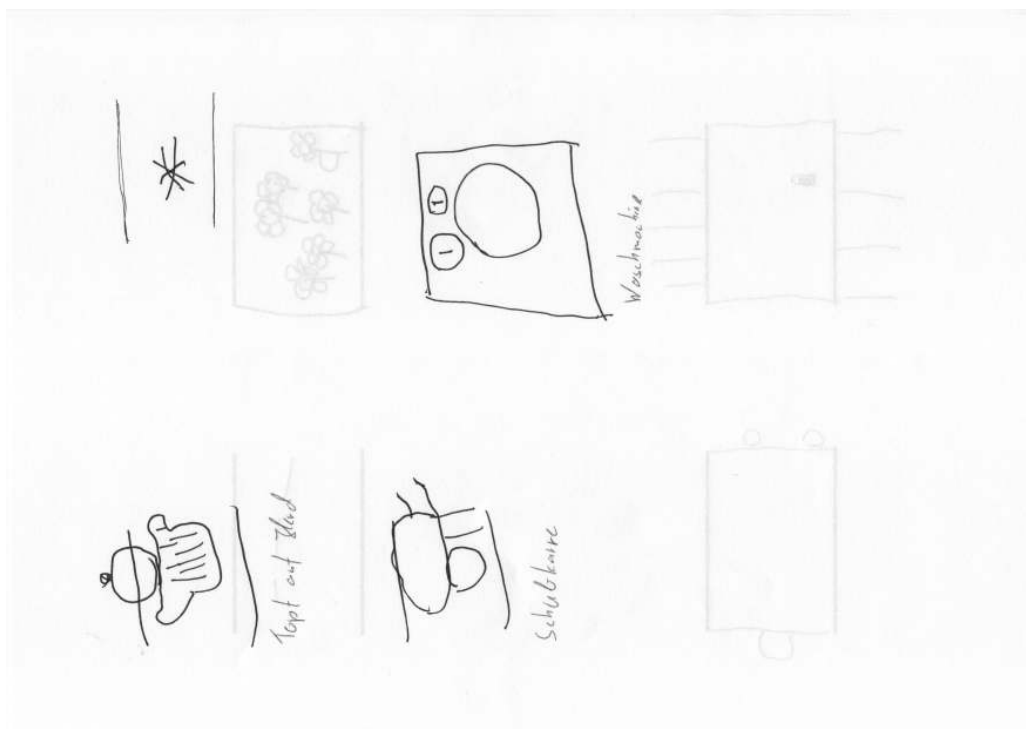


Figure 40: Sheet 1.4 - 13 unique Interpretations in total

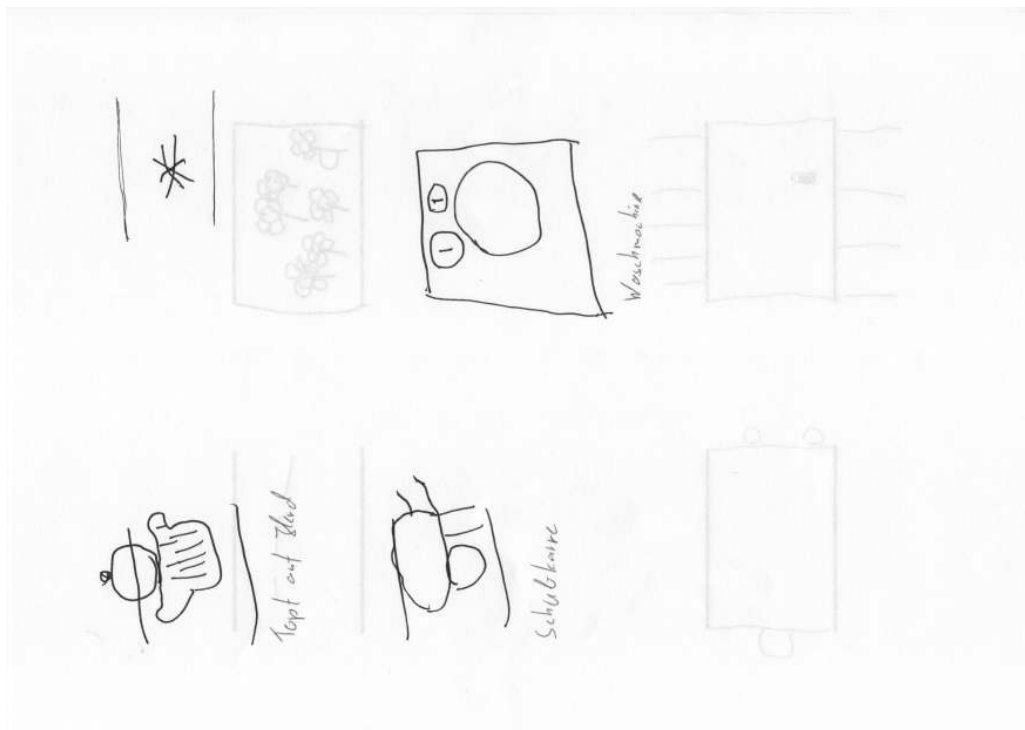


Figure 41: Sheet 1.5 - 17 unique Interpretations in total

More complex figure (see right one in figure 29):

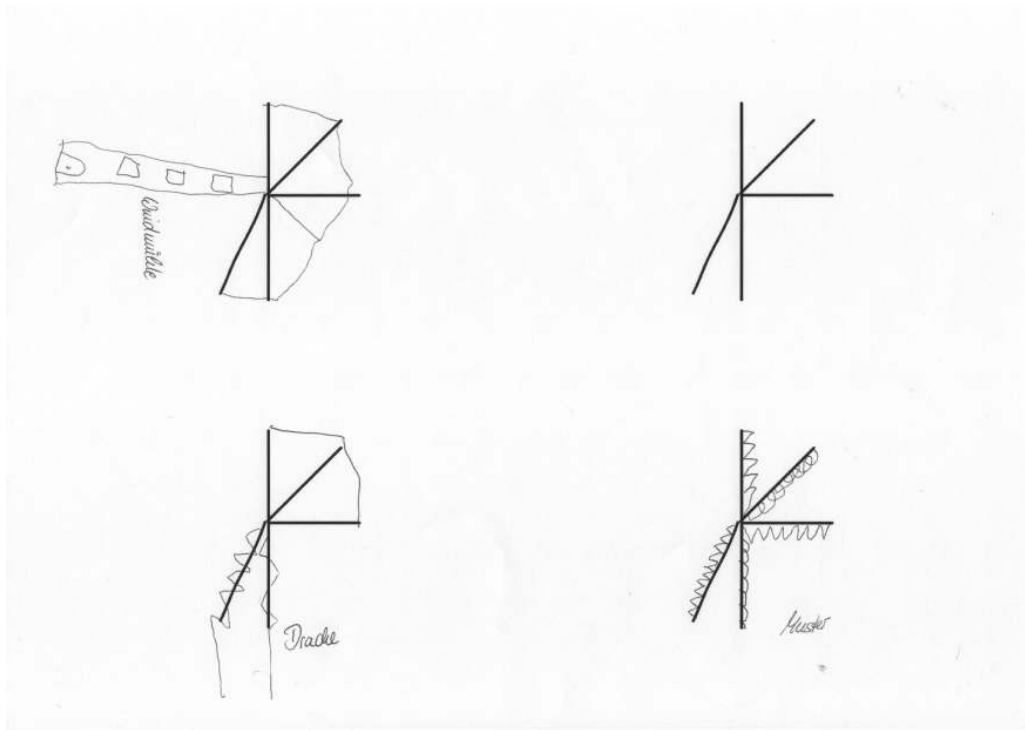


Figure 42: Sheet 2.1 - 3 unique Interpretations in total

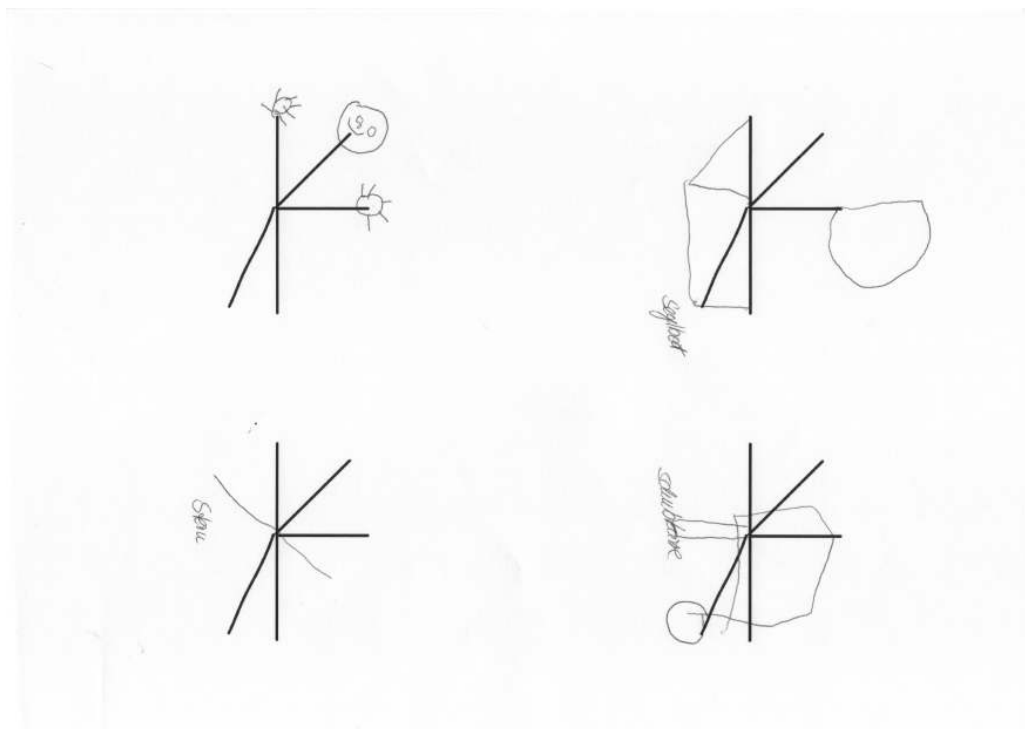


Figure 43: Sheet 2.2 - 7 unique Interpretations in total

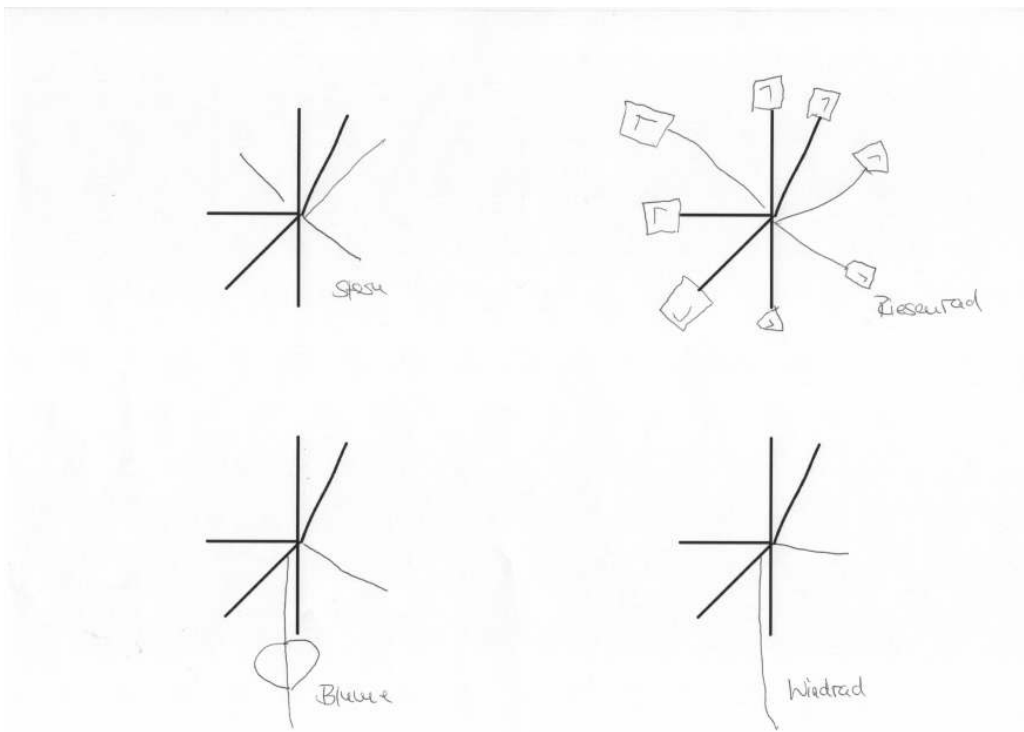


Figure 44: Sheet 2.3 - 10 unique Interpretations in total

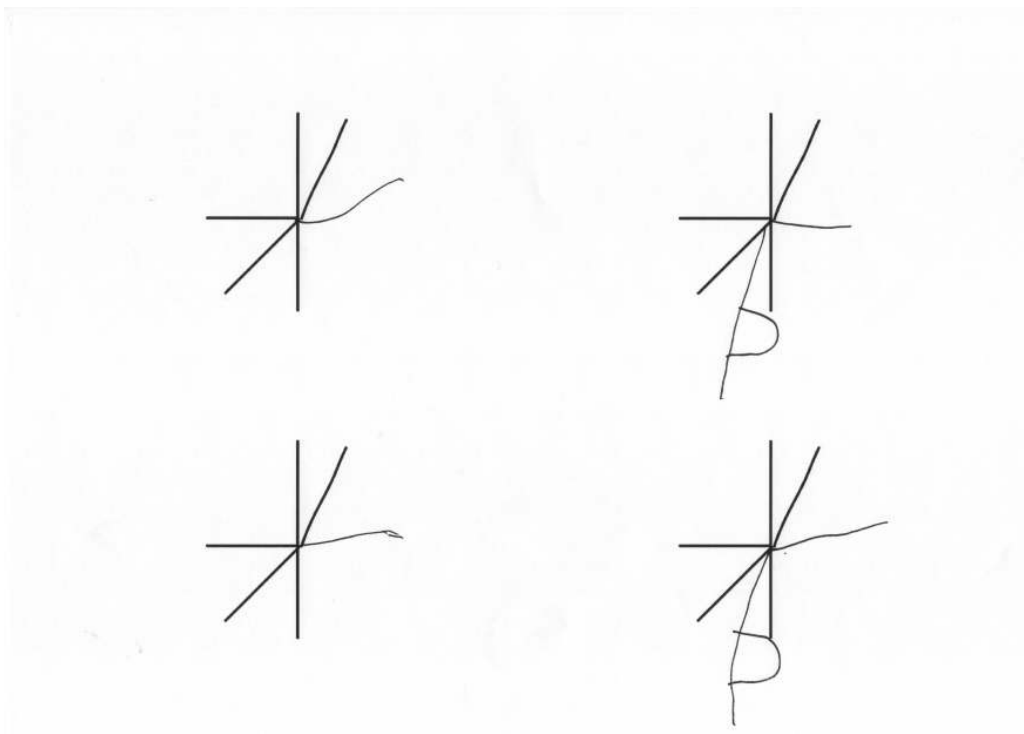


Figure 45: Sheet 2.4 - 10 unique Interpretations in total