ABSTRACT

In this paper, we explore alternative ways to visualize search results for children. We propose a novel search result visualization using characters. The main idea is to represent each web document as a character where a character visually provides clues about the webpage’s content. We focused on children between six and twelve as a target user group. Following the user-centered development approach, we conducted a preliminary user study to determine how children would represent a webpage as a sketch based on a given template of a character. Using the study results the first prototype of a search engine was developed. We evaluated the search interface on a touchpad and a touch table in a second user study and analyzed user’s satisfaction and preferences.

Categories and Subject Descriptors
H.5.2. [User Interfaces]; H.3.3. [Information Search and Retrieval]

Keywords
Result visualization; Information retrieval; Search engine; Children; User-centered design.

1. INTRODUCTION

The number of children who use the Internet is increasing year by year [16, 32]. The German 2012 KIM study [32] reports that about 62% of the children of ages six to thirteen use the Internet, and 70% of those use search engines. They use the Internet for research related to their school activities (52%), for entertainment, e.g. online games (45%), and for information gathering related to celebrities (43%), news (35%) etc. According to [31], more than half of the children search the Internet mainly without an adult. Therefore, there are special search engines available that aim at supporting children during information acquisition.

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In particular, they only retrieve child appropriate content in the WWW.

Another important aspect is the usability of those search engines. Search engines need to match the particular skills of children to increase their usability for this specific user group. The majority of the engines have a colorfully designed start page to attract children’s attention (e.g. kidrex.org, dipt.com, askkids.com, blinde-kuh.de, helles-kopfchen.de, quinturakids.com). In every other aspect, existing web search engines for children still have a similar design as common search engines and do not always match the skills and abilities of children [12]. This may be a reason for children to experience difficulties during information acquisition. Not all children succeed in information inquiry and especially younger children experience difficulties [32].

We aim to increase the usability of web search engines for children. Therefore, we explore alternative ways to visualize search results for children and propose a novel approach. The main idea of this approach is to represent each web document as a character where a character visually provides clues about the webpage’s content. The research questions addressed in this paper are: How would children map a web document to a character? How to visualize search results using characters? Does the character approach improve children’s experience with search engines?

2. RELATED WORK

Information retrieval for children is a broad topic. A survey about information retrieval (IR) for children in general, where all the components – both user interface and algorithms – of an IR system are covered, is given in [15]. The survey explains the specifics of young users, i.e., their cognitive skills, fine motor skills, knowledge, memory and emotional states and how they differ from those of adults. It describes previous user studies about children’s information-seeking behavior1, e.g. [2, 3](seventh grade), [4](ages 9-12), [25](ages 8-12), [26](ages 8-10), [27](sixth grade), gives an overview of retrieval algorithms, e.g. [18], and search user interface (SUI) concepts, e.g. [24], and describes existing information retrieval systems for children, specifically web search engines and digital libraries, e.g. [23].

Overall, there are several conceptual challenges in the design of search systems for children. Children require emotional, language, cognitive, memory, interaction and rele-

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1Information-seeking behavior is user’s behavior during the process of information acquisition; it describes how people search for information [22, Chapter 3].
vance support [13]. This means that children can easily get frustrated, have difficulties to formulate queries due to a small vocabulary and errors in spelling, have difficulties with thinking abstractly, can process less information than adults, have difficulties with complex interactions and have difficulties to judge the relevance of the retrieved documents to their information need. In the following, we provide more details about the aspects that are in focus of our research.

2.1 SUIs for Primary School Children

Previous research suggests alternative ways for children to formulate a query like using a predefined word dictionary in JuSe [37], a set of tangible objects which represent the search terms in TeddiIR [24], a visual querying interface in Emma Search [9] or browsing using categories represented by icons in the International Children’s Digital Library [23].

Kammerer and Bohnacker [26] suggest an interface that allows manipulation of search query terms to explore alternative search result sets extracted from the original query. Thus, the proposed interface supports children by abstraction of their information needs in terms of keywords. Coll-Age [17] is a SUI that combines search results for children’s web queries with additional child-oriented multimedia results which provide further relevance clues for children. Elliot et al. [10] and Glassey et al. [11] presented a mockup of the results presentation interface and used text size in a snippet as an indicator for result relevance.

To support children in interaction, the touch interface ImagePile [1] was proposed. It displays the results as a pile of images where the user navigates horizontally instead of the commonly used vertical scrolling. This coverflow visualization can be operated with simple click-and-point interactions, thus, making the usage easier for children whose fine motor skills are not fully developed yet.

Another SUI is the Knowledge Journey (KJ) [13, 14] that was designed for primary school children. It supports children in different ways, providing emotional, language, cognitive, memory and interaction support. KJ has acoustic tooltips, contains possibilities for both, searching through text input and navigating using menu categories, has a guidance figure for emotional support and a result storage functionality to support cognitive recall. KJ is also adaptable towards individual user characteristics allowing a flexible modification of the SUI in terms of UI element properties like font size, but also UI element types and their properties.

To our knowledge, only the International Children’s Digital Library [23] was co-designed with children (age six to eleven).

2.2 Presentation of Search Results

An important part of a SUI is the visualization of search results. Common presentation forms of search results that are currently in use are described in [22]. Usually search results are displayed as a vertical list of information summarizing the retrieved documents. An item in the result list consists of the web document’s title, source (URL) along with a brief summary of a relevant portion of the document. This collection of information is also called document surrogate [22, Chapter 5]. The surrogate’s content aims to provide relevance clues, i.e. help the searcher to judge the relevance of the document before seeing it. Given a query, so called query-oriented summaries are provided, which contain text references to the terms within the query. Furthermore, query terms are highlighted to make them more visually salient, which enables a faster information access.

A summarization of preattentive techniques for visualization of information relevance is given in [7]. Preattentive techniques allow a user to unconsciously accumulate information before actively focusing on an information entity. They do not require much effort or attention of a user. Features such as the search results’ position, orientation, color and intensity, size, animation, and stereoscopic depth have been discussed in terms of their effectiveness, comprehensibility, and visual interference and evaluated with adults. Based on the previous research, e.g. [28], animation, color and size are promising features for children. However, the usage of these features as relevance clues should be evaluated in future user studies.

Most search engines for children use a vertical list visualization of search results similar to common search engines. However, the surrogates of some search engines for children also contain a webpage’s picture. Furthermore, surrogates in search engines for children may also contain information about rank, result’s category, the target age group or reading level (e.g. see Fig. 1).

Previous SUIs for primary school children use three basic forms of search result visualization, i.e. a vertical list visualization of search results (e.g. Emma Search), coverflow (e.g. Knowledge Journey, ImagePile) or tiles (e.g. International Children’s Digital Library). They also use a “standard” surrogate visualization as a block that contains a webpage picture or thumbnail, title and textual summary. To our knowledge, they was no research on how children would represent a webpage as a surrogate, what information they would consider to be important and how they would visualize it. This research is important to support children during relevance estimation. Therefore, in this work, we investigate an alternative visualization of search results for children with characters following a user-centered development approach.

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Figure 1: 1st search result of the German search engine Blinde-Kuh is shown. The surrogate contains meta information about web documents, e.g. the target age group in categories “S”, “M”, “L”, “XL” for children from six to thirteen.

3Relevance is a measure of how closely a given web document matches a user’s information need. This judgment is done by the user and depends on different factors, e.g. his domain knowledge, the context of the search, previously seen results.
2.3 Usage of Avatars

The idea to use characters for search result visualization is related to the usage of avatars in user interfaces. For example, the avatar idea was employed in music information research. Haro et al. [21] suggested to use a musical avatar to visualize a user’s musical preferences. Musical preferences of a given user are mapped to the visual domain. Specifically, music genre, mood and other features are mapped to avatars head, eyes, mouth, hair, hat and instrument. Moreover, avatars have been used in SUIs for children in a role of a guidance figure that provides additional support for children, e.g. by spell checking [9, 13]. Children like to have a guidance figure, thus, an avatar creates an emotional bond with an SUI which increases children’s willingness to accept its help during the search [13].

3. CHARACTER CONCEPT

3.1 Idea and Advantages

Appropriate metaphor: As proposed in [33], the idea to represent a webpage as a person or character is motivated by the fact that children often ask adults about information they would like to know. Vygotsky [39] describes this process in his social development theory. He argues that a child learns many important things through social interaction with a skillful tutor and social factors play a role in a child’s cognitive development. A skillful tutor can be a parent, a relative, a person in the child’s environment or another child, e.g. a schoolmate. Therefore, information exchange between people can serve as a metaphor for searching for information on the Internet. Each webpage is a person that can explain some facts to a child.

Visual clues: It is also known that images better match the cognitive skills of children than written words [19]. Therefore, we suggest to visualize each search result as a character, where a character visually provides clues about the webpage’s content.

Motivation factor: Furthermore, search result visualization with characters is playful and will bring children likely more joy than just textual labeling of search results. Therefore, this approach is a means of emotional support for children as positive disposition towards the system keeps them motivated.

3.2 Template Structure

We considered the following criteria for a character design to be important: simple and concise layout, adding features through layers is easy, cute and fun design.

Simple and concise layout: Characters can serve as a unique representation of a web document, i.e. each character is unique. However, this method is not feasible due to the huge size of the Internet. Another solution is to use a template of a character and map different webpage features to the template parts. In this way, a compromise between a characters’ individuality and its adaptability for all pages can be found. By analyzing popular applications for children, a compromise solution was found. Nintendo has Wii avatars also called Mii which are characterized by a template with a few degrees of freedom. All avatars have a simple 3D template which is enriched with features that make the figure customizable without large deviation from the basic template. Generated avatars look similar, however small face adjustments make them unique.

Adding features through layers is easy: A character template can be designed in different ways. The challenge in this work was to design a child-friendly character which is also adaptable. Therefore, we chose a comic look for the characters, similar to [21]. Characteristics of comic characters are easier to recognize because they are displayed superimposed. Comic characters are a popular medium and well known to children. They have a simple look and bring both fun and game feeling, which is not achievable with realistic characters. Furthermore, we decided to create a 2D template of a character. A 2D template is simpler than a 3D one and allows the creation of a character with less computational effort.

Cute and fun design: In order to achieve a cute and fun design, we decided to use anime styles, specifically a Chibi [5] like character. Chibis’ head size is large. It is equal to the size of the body. This makes the character look cute because of the resemblance with babies. The final process of character development is shown in Fig. 2. Vector graphics were created from the drawn pictures.

3.3 Visualized Features

The type of features that should be visualized with the character’s help presents an open question. We propose to divide features into two categories: explicit and implicit. Explicit features come directly from the webpage’s elements such as text, images, background color etc. Implicit features, on the other hand, have to be extracted from the webpage first, using diverse algorithms. Examples of implicit features are the webpage’s topic, the age of the webpage (time of the last modification) or the webpage’s complexity in terms of text size or reading level.

The number of features that should be visualized by a character presents an open question as well. The more features a character reflects, the harder it is to learn and recognize the coded information. According to Piaget [36], children in primary school age are in the concrete operational stage of their development. The concrete operational stage takes place from around ages 7 to 11. It is characterized as a stage where children learn to reason logically and have difficulties with abstract thinking. They can classify physical objects according to several features and order them along a single dimension such as e.g. size [35]. Children are also able to coordinate at most two dimensions of an object simultaneously [35]. Therefore, we suggest that the number of coded features for children of this age is limited to two.
4. WEBPAGE MAPPING BY CHILDREN

We conducted a first user study in order to investigate how children would represent webpages by a sketch based on a given coloring template of a character. Children’s interest in painting was used as a motivation factor to participate in the study. Painting is known as an effective tool in the user interface development with children [8, 34, 40].

4.1 Tasks

We had two tasks. For the first task, children had to assign one or several colors to a topic. This information could later be used to decide on a colour coding of the webpage topics. We selected topics to support both educational and entertainment needs of children, as recommend in [28]. Specifically, we chose topics like games, sports, hobbies, leisure, news, science, nature, travel (geography) to also meet the information needs of children described in [29].

For the second task, children painted a sketch of a character in order for it to represent a specific webpage. For this, we selected web documents for children from different topics described above. Character templates and web documents were printed in A4 format. After studying the webpage, children drew a character that they would associate with the page. Children could paint as many webpages as they liked. Web documents were selected randomly for each child. We did not provide information about the webpages’ topics to the participants. After each painting was finished, we asked the children to explain what they had drawn and why using a follow-up interview.

4.2 Results

The study was conducted in June 2013 during Magdeburg University Science day where the public is free to visit exhibits provided by the university researchers. This event always attracts much attention of parents with children. The children were approached and asked if they wish to participate in the study. Their parents signed the consent form and were free to visit other exhibits in the meantime. We used a large table in the hall for participants to paint. Children worked individually on their study assignments and were supervised by study conductors. Children used coloring markers and pencils for paintings.

18 Children participated in the user study, eleven boys and seven girls between six and thirteen (see Table 1). The first task was solved by 17 of 18 children. A six year old child could not solve the task because he did not understand the connection between a topic and a color. This conforms with human development theory of Piaget [36] that states that younger children have difficulties with abstract thinking.

The results of the first task show that the children could easily assign colors to half of the topics. These topics are nature, news, games and science (see Table 2). The children probably had differing associations with other topics and therefore the variety of colors is larger. In order to determine a color for topics with a small agreement among participants, we used topic colors that were chosen by a high percentage of participants (green, blue, orange). We assigned topics to one of the three groups (each group had a topic with a dominant color assignment) and sorted them by the degree of membership to education and entertainment topics. The dominant colors were interpolated on the remaining topics using a color gradient. The final color assignment is shown in Fig. 4.

For the second task, the participants were asked to paint a webpage using a character template. Four participants (among them also older ones) did not understand the task. One participant (thirteen years old) understood the task, had however no ideas what to draw. Furthermore, some older children did not know how to implement their ideas in pictures. In that case, children were given other webpages to work with. Fig. 3 depicts the most interesting paintings and the corresponding (German) webpages. In the following, we briefly summarize the explanations of the children regarding their paintings:

**Example 1 (Fig. 3a) Webpage about German family in Spain:** The colors of the character’s t-shirt represent Germany and Spain. The blue head represents water [an island was mentioned in the text]. A green color was used because the text mentioned nature. The sun was painted on the pants because the webpage is about Spain. Gray color was used because of the mountains. “They are hiking in the mountains,” the boy said [mountains were mentioned in the text].

![Figure 3a](image-url)

### Table 1: Demographic data of participants.

<table>
<thead>
<tr>
<th>Age</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>#</th>
<th>Øage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>9,71</td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Overall</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>18</td>
<td>9,89</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2: Color distribution:** 59% of the children assigned a green color to the nature topic, remaining participants suggested three other colors. For the sports topic there were two dominant colors that received an equal number of user’s votes.

![Figure 4](image-url)
Example 2 (Fig. 3b) Webpage about sightseeing in Paris: The character has both “boy and girl” hair. The exclamation marks represent “information, a lot of text.” The text header “Paris” was used because Paris is mentioned in the webpage’s text. World atlas was painted on the head because Paris is “famous, known everywhere.” “Blue (color on the t-shirt stands) for lots of information.” “Yellow (color on the pants) because one becomes smarter.” The boy also painted a brain to show that the reader gets “smarter and cheerful.”

Example 3 (Fig. 3c) Webpage about scavenger hunt [The website has a textual description of the game and a picture of a hand reaching for tree branches.]: The character is a girl “just like that.” The characters’ clothing also has no special meaning. The girl painted trees and nature because the game described in the text is outside. She painted different paths and markings because the webpage’s title is scavenger hunt.

Example 4 (Fig. 3d) Webpage about spring season [The website has a text about spring and the beginning of spring and two images of snowdrop flower and pussy-willow]: The girl painted four seasons as the character’s background. The character is a girl because of “personal” reasons.

Example 5 (Fig. 3e) Webpage about sightseeing in Paris: The character has a skin color and hair “like a normal person.” The character wears a blue jacket and jeans like “normal people”. The character is “going to Paris.” It has one baguette because a baguette is “typical for France.” It also has a bag because one needs a bag for travelling. The french flag is painted on the bag. [Baguette, bag and flag are not explicitly mentioned in the text and are not present on the webpage’s images.] The character imagines what he is going to visit in Paris. That is why thought bubbles are painted where each Paris sight is shown. [The images of the sights are similar to the ones on the webpage.]

Example 6 (Fig. 3f) Webpage about mathematics, milliliter to liter conversion: A thought bubble was painted on the character’s forehead “so that children know they have to count”. T-shirt has a text “milliliters conversion” taken from the webpage. The character has “normal” hair and pants.

Overall, children depicted explicit features of webpages such as text and images and implicit features such as objects or colors which to them represent the topic. Interestingly, many children tried to humanize the character by drawing hair or complexion. A summary of depicted features and techniques applied by children is shown in Table 3.

22% of the children embedded objects which were directly mentioned in the text or were a part of a webpages’ image. For example, a squirrel was added to the character’s surrounding because the web document contained text about squirrels. 17% of the children also incorporated text from web documents in their drawings (e.g. Fig. 3b,f).

44% of the children used colors and 33% depicted objects associated with words in text or webpage’s images. For example, a character’s head was painted in blue because the text contained information about water, and a sun was painted because the webpage was about Spain (Fig. 3a).

28% of the children drew outside the character. 17% of the children painted the character’s surrounding to show the context (e.g. Fig. 3c,d). However, the characters itself do not provide any information about the webpages. The information about the webpage was drawn around the character. 11% of the children attached objects and features to the character, e.g. a lightsaber to depict a webpage about computer games. One child embedded the character in a scenario: Fig. 3e shows that the character is set in the context of Paris and travel. Therefore, Paris related objects such as baguette, and travel related objects such as hat and bag were painted. Thought bubbles were used to show that the
character is going to visit different sights in Paris, a bubble for each sight, because the webpage was about traveling to Paris.

One child (6%) employed many techniques. He depicted meta information about the webpage in his drawing using symbols (e.g. to express information complexity in Fig. 3b). The child also used colors in his other drawings, e.g. to describe emotions about the content. He used orange for fun to signal that the web document is about games and blue for cold to signal that the webpage is about winter song lyrics.

5. SEARCH USER INTERFACE

Most of the children that participated in the study were able to depict a webpage using a character. This encouraged us to continue along this design path and to make some decisions about the SUI design based on the study results. For the first prototype, we concentrated on the design of the characters and the SUI layout. For the character’s design we used the ideas from the children’s paintings such as thought bubble, the inclusion of a background, the use of color, the characters’ humanization with hair and complexion, and the collapsing of character accessories into the subject categories.

We also considered webpage features that children paid attention to in the study. However, as too many coded features are considered to be difficult for children to comprehend, we decided for a character to depict two webpage features: One feature used by the majority of children in the user study was the association with words or images. For association we used topics. Topics are a level of abstraction, e.g. a set “bag, flag of Germany, flag of England, airplane, bus, train” can be summarized as a travel topic. The number of topics is significantly smaller than the possible number of low-level subjects. Therefore, it is easier and faster for children to learn the meaning of each topic representation.

We used a dual coding approach to depict topics. The topic information is visualized using the colors which were determined in the first user study. Characters representing different topics have a specific clothing color. We also used the idea from the user study about painting a character’s surrounding to show the context. Characters representing different topics have a specific background (e.g. Fig. 6). For example, a character that belongs to the “Nature” topic has a landscape with trees around it (as seen in children’s paintings Fig. 3c,d). Thus, topic information is dually coded with colors and background images.

Another feature was a representative picture from the webpage. For this, we used the children’s idea about comic elements such as thought bubbles. Each character has a thought bubble with further explicit information about the webpage’s content such as a representative picture from the webpage (see Fig. 5a, left). In order to distinguish between different characters which belong to the same topic, character elements such as hair, glasses, hat, shoes, eyes and lips shapes are used. Thus, a particular webpage has a distinctive combination of those elements.

The SUI itself (see Fig. 5) has an input field for textual queries. Under the input field a category bar is placed. A category bar consists of eight topics which are visualized as boxes. Boxes transmit both background and color information at the same time. This makes it easy to associate each search result with the corresponding topic. The category bar also provides information about which topic the search results belong to. If a topic is not represented among the results, the box is faded.

We designed two versions of search result visualization using characters. The first one, called Alice (Fig. 5a), is an analogue of coverflow. Coverflow was found to be the best choice for younger children [13]. The selected element is clearly separated from the rest and a user can concentrate on one item at a time, thus resulting in a smaller cognitive load. The second version, called Tim (Fig. 5b), is an analogue of the list result visualization and is meant for older children. A vertical list of surrogates offers a fast overview of several results at once. By clicking on the snippet the result webpage is opened in the same window. The same window was chosen to better support the children’s navigation in the search engine and to prevent backtracking [13].

For the backend we used Lucene6 to create a search index. Our index contained 311 web documents7 selected from webpages for children to assure a high quality of search results. In comparison, other research used 60 web documents for children [13], the Bing Search API [14] with general web documents or no information was provided about the backend (e.g. [9]). Each document was manually assigned to one of the eight topics. We also used the Readability.com8 API to process web documents in order to show them in a clean and readable view (common format, no advertisement) which makes it easier for children to read. Our application also works with touchscreen devices. We think that touch

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7A subset of these documents (25 documents) was used in the first user study.

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<table>
<thead>
<tr>
<th>feature category</th>
<th>webpage feature</th>
<th>technique</th>
<th>( N )</th>
<th>%</th>
<th>age</th>
</tr>
</thead>
<tbody>
<tr>
<td>explicit</td>
<td>objects described in text/image</td>
<td>drawings</td>
<td>4</td>
<td>22%</td>
<td>7.8,13</td>
</tr>
<tr>
<td>text</td>
<td>usage of colors</td>
<td>incorporation</td>
<td>3</td>
<td>17%</td>
<td>10,11</td>
</tr>
<tr>
<td>implicit</td>
<td>associations with word or image</td>
<td>usage of colors</td>
<td>8</td>
<td>44%</td>
<td>6,8,9,10,13</td>
</tr>
<tr>
<td>context</td>
<td>drawing of objects</td>
<td>6</td>
<td>33%</td>
<td>6,8,9,10,11</td>
<td></td>
</tr>
<tr>
<td>meta-information</td>
<td>usage of symbols</td>
<td>1</td>
<td>6%</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>emotions</td>
<td>usage of colors</td>
<td>1</td>
<td>6%</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Depicted features and techniques applied by the children (n=18) during the study, participants’ number and age.
interaction is more natural for children than the usage of mouse. Touchscreen devices also become a part of our everyday life in the form of smartphones.

6. USER STUDY

The goal of this user study was to evaluate usability aspects of the SUI with characters. We had the following research questions: 1) Can children recognize topic information depicted by a character? 2) What is the children’s attitude towards the new SUI? 3) What search engine would children prefer to use afterwards, with characters or the one they used before? 4) What search result visualization, Alice or Tim, do children prefer and why?

6.1 Study Design

Our user study was designed as follows: we used a pre-interview to gather children’s demographic information, their Internet and touch device experience. Then a lab experiment was performed using two versions of the SUI with characters, Alice and Tim. In order to reduce the bias due to the order in which the participants are using the UI, we applied a latin square design. Thus, half of the participants were asked to use Alice interface first and then to use Tim, whereas the other half did this in reverse sequence. Using each interface, children performed a task-oriented search, i.e. focusing on the completion of a particular task. In addition, we took notes about participants’ unexpected behavior. After that, children were interviewed about UI features they liked most or disliked and what could be done to improve the SUI. Finally, we asked the participants what user search interface they preferred. The supervisors encouraged the participants to share their opinion to help the scientists build better search engines for children.

We used search tasks during the lab experiment as we believe a search task helps the participants to better explore the SUI in comparison to try-out sessions without a particular task. The search tasks were administered verbally. Children were asked to enter a pre-defined query for each task. The search tasks were designed to show the benefits of the visualization of topic information with characters: Task 1: Find out the location of the Persian Gulf (German “Per- sischer Golf”) using the search query “golf”. Task 2: Find out the names of three species of mice using the search query “mouse”. The predefined queries were ambiguous. For example, in task 1, there were results about golf as a game and golf as a bay. Knowing the result topic, one was able to determine the relevance of a search result in a more efficient way.

Figure 5: Screenshot of the SUI with characters: a) horizontal result arrangement (“Alice”). Search for (German) “golf”, first four results are shown (left), third result was clicked (middle), third result is opened (right); b) vertical result arrangement (“Tim”). Search for (German) “mouse”, first three results are shown (left), second result is opened (right).

Figure 6: “Nature” topic design: character’s surrounding to show the context, a pair of characters that represent two different webpages and a final character design.
way. After a child entered a query, he or she was also asked to assign each of the first three search results to one of the eight topics.

Two touch devices were used in the user study, an Apple iPad and a 30-inch touchscreen tabletop Microsoft Surface 1.0. Each participant performed a lab experiment individually, either using the touchpad or the touch table. Children were randomly assigned to one of the devices. For efficiency reasons we conducted experiments on both devices in parallel with a supervisor each. The session lasted on average 30 minutes.

Participants: The study was conducted in July 2013 during children’s university days. 22 children participated in the user study, twelve boys and ten girls between six and twelve (see Table 4).

<table>
<thead>
<tr>
<th>Age</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>#</th>
<th>Øage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>12</td>
<td>9,58</td>
</tr>
<tr>
<td>Boys</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Overall</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>22</td>
<td>8,86</td>
</tr>
</tbody>
</table>

Table 4: Demographic data of participants.

The distribution according to the frequency of the Internet usage is similar to the one in [32]. In our study, 51% of six and seven year old children use the Internet very seldom or did not use it at all, whereas 88% of older children use the Internet at least once a week. However, in our study, we had more younger children who had Internet experience than in [32]. 68% of the children use the Internet without supervision. The distribution is uniform over the various age groups. Children use the Internet mostly to play online games (68%) and search for information mainly regarding homework (36%). In order to search for information, 68% of the children use Google.de, 23% use the search engine for children Blinde-Kuh.de. Less than 10% of the children also mentioned the search engines for children FragFinn.de and Helles-Koepfchen.de. Participants were familiar with touch devices: 68% of the children had used a touch device before, among them 50% of the six and seven year old children.

6.2 Study Results

Character mapping: The children were asked to assign each of the first three search results to one of the eight topics. In total, there were six search results with different topics given two interface versions and tasks. The largest recognition rate was 90%, i.e. 90% of the children correctly recognized that a search result belonged to the sports or travel topic. The leisure topic had the smallest recognition rate, it was recognized by 50% of the children. We observed, however, a positive learning effect: Using the second interface, three characters from the other three topics were correctly identified by all 22 subjects and the maximum error rate was only 25%. We noticed that the characters helped the children to be more efficient. Especially in the first task, they skipped the first characters with the wrong topic and directly selected the right result. However, more accurate data should be collected in the future.

User satisfaction: 76% of the children assessed our SUI with characters as easy to use. The rest of the participants (six and seven year old) gave a negative assessment because they had difficulties with reading texts and had to read too much. Younger children had difficulties with reading and supervisors had to help them by reading the texts for them. Therefore, a text-to-speech function should be provided for those children. One twelve year old child wished that the results were sorted by the topic. He told us that he had attention difficulties (ADHS). The children assessed the arrangement of the elements on the screen (on a five-point scale) as very good (29%) and good (57%). The Alice layout was criticized because too much free space was not used. The children assessed the presentation of results with characters (on a five-point scale) as very good (43%) and good (52%). The children assessed the design of the characters (on a five-point scale) as very good (52%) and good (33%). However, the participants opinion was divided. Whereas the younger children found the figures rather “funny” and “nice”, the older participants would have preferred “more professional” figures and assessed the used ones as “odd”. The children assessed the characters as being very helpful (57%) and helpful (24%) in topic recognition (on a five-point scale).

Search engine preferences: The new SUI received a positive response: 50% of the six and seven year old, 67% of the eight and nine year old, and 11% of the children between ten and twelve found it to better than the ones they used before. The rest of the participants between six and nine were unsure or found both to be equally good. Only the children between ten and twelve appeared to be more biased towards the conventional search engine Google (44%). However, the only explanation we received after asking for the preference reasons was “because Google is cool.”

We also experienced that children have associated the search user interface with the used device or the search task difficulty, indicating the lack of abstraction. For the usability questions, supervisors had to emphasize the fact that children were asked about the SUI and not the devices or the search task.

Layout preferences: Comparing the two layouts (Fig. 5) the children preferred the Tim (52%) over the Alice (24%) layout, the rest of the children could not decide. The results are summarized in Fig. 7. Against our assumption, even younger children (six and seven year old) had a preference towards the Tim (33%) over the Alice (17%). However, 50% of the children were uncertain. The children did not like that in Alice they had to do one extra click to get to the webpage content. They preferred to see the textual summary right away and to be able to view several results at once as in the Tim layout. “One sees a bit of text right away and can have a look (at the web page) straight away.” Children who chose the Alice liked the layout simplicity and visual attractiveness. Alice is “lovely”, “easier”, “does not have as much text (as Tim)”.

Touch and Devices: Participants who used the Apple iPad rated search tasks to be more difficult than the ones who used the Microsoft Surface, especially for the second search task (iPad, 25% and Surface, 70% of the children found the task to be easy). For the second search task, one had to do more navigation effort of going to the next result page in contrast to the first task, where the answer could already be found on the first result page. The screen size of the iPad is smaller than the one of the Microsoft Surface and it is harder to read the coded topic information. 86% of the children found the browsing of the search results to be easy.

9We used a Likert scale from very good to very bad. Each scale was visualized with smileys. This “Smileyometer” [38] was shown to the participants.
A user creates a character using the library to provide an example scenario (see [6, 20]), where the character represents an abstract search query. One can use a library for supporting children in relevance estimation described in [13], i.e. help children judge the relevance of a document based on its surrogate. The results of the second study indicate that the SUI we developed is mostly preferred by eight and nine year old children. We determined advantages and disadvantages of two possible layouts for search results, and a stronger preference towards the Tim layout.

This work has also some limitations. We used a wide age range of children in our studies. However, it helped us to determine the specific age of a target group that would use our SUI (eight and nine year old children). We can focus on these children in the future. We also left out the comparison of user studies (Sect. 4 and Sect. 6) show the potential of search result visualization with characters. We were able to determine children’s view on web pages, what features of a web page are important for children and how they would visualize them. This takes us a step further in the direction to support children in relevance estimation described in [13].

8. CONCLUSION & OUTLOOK

We introduced a novel search result visualization for children using characters. The idea of this technique is to represent each web document as a character where a character visually provides clues about the web document’s content. We believe that this technique has several advantages for children such as appropriate metaphor for a person a child can get answers from, visual clues are better than textual clues for children to comprehend, and a playful view is supposed to bring children more fun. Following a user-centered development approach, we first studied what webpage features children would depict using a given sketch of a character and how they would do this. We also showed how characters can be incorporated in a search user interface. We evaluated children’s satisfaction while using the SUI with characters in a second user study and got promising results. In the future, it is also of interest to extend the number of depicted webpage features, e.g. by adding text complexity.

9. ACKNOWLEDGMENTS

We would like to thank all participants of the user study. We are very thankful to the reviewers for their appropriate and constructive suggestions on how to improve the paper.

10. REFERENCES


