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Young children's storybook searching with a visualized search interface

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Abstract

Purpose – The purpose of this paper is to explore how young children interact with a visualized search interface to search for storybooks by assembling the provided visual searching items and to explore the difference in visual search behaviours and strategies exhibited by pre-schoolers and second-graders.

Design/methodology/approach – The visualized search interface was used to help young children search for storybooks by dragging-and-dropping story characters, scene objects and colour icons to perform search queries. Twenty pre-schoolers and 20 second-graders were asked to finish a search task through the visualized search interface. Their activities and successes in performing visual searches were logged for later analysis. Furthermore, in-depth interviews were also conducted to research their cognitive strategies exhibited while formulating visual search queries.

Findings – Young children with different grades adopted different cognitive strategies to perform visual searching. In contrast to the pre-schoolers who performed visual searching by personal preference, the second-graders could exercise visual searching accompanied with relatively high-order thinking. Young children may also place different foci on the storybook structure to deal with conditional storybook queries. The pre-schoolers tended to address the characters in the story, whereas the second-graders paid much attention to the aspects of scene and colour.

Originality/value – This paper describes a new visual search approach allowing young children to search for storybooks by describing an intended storybook in terms of its characters, scenes or the background colours, which provides valuable indicators to inform researchers of how pre-schoolers and second-graders formulate concepts to search for storybooks.

Keywords Libraries, Children, Library management, Storybook searching, Visualized search interface

Paper type Research paper

1. Introduction

Access to books and engagement in book reading activities have been shown to improve language literacy development in young children (Newman, 1996). Additionally, when young children are allowed to make their own decisions

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regarding book selection for reading, their active engagement in the reading process helps them develop a close interest in reading such that they become lifelong readers (Kragler and Nolley, 1996; Swartz and Hendricks, 2000). Many studies have indicated that young children's vocabulary and reading capabilities are limited (Bilal, 2000; Large and Beheshti, 2000), and that young children like to select storybooks based on personal interest, a storybook cover or a book summary (Swartz and Hendricks, 2000; Gibson, 2011). However, as traditional keyword-based search techniques and interfaces are mainly designed for adults, young children may encounter difficulties in transforming personal interest, images of stories or story summaries into effective keywords to fulfil their need to select storybooks in a digital library (Druin, 2005; Gossen and Nürnberger, 2013). In this regard, and due to the rapid growth and abundant types of digital books available, there is a need to facilitate the way in which young children browse and search for books in such an environment (Hutchinson *et al.*, 2006).

Many studies have proposed alternative approaches to the problem of young children's book selection by the use of visual searching and representation. Among these approaches, hierarchical catalogues (e.g. Borgman *et al.*, 1995; Busey and Doerr, 1993) enabled children to find books by identifying the correct categories through navigating hierarchical structures of categories, without the need to recall or type keywords. However, young children may have difficulty understanding abstract categories (Hutchinson *et al.*, 2006; Hirshh, 1997; Bilal and Wang, 2005) or may become disoriented when navigating hierarchical structures (Borgman *et al.*, 1995). Accordingly, a flattened category approach (Hutchinson *et al.*, 2006; Bilal and Bachir, 2007), which transforms hierarchical categories into a single layer of categories, has been adopted to alleviate this difficulty. This successful approach encourages young children to select appropriate categories and then browse the results for their desired information.

In addition, young children often intuitively articulate their needs in natural language (Jochmann-Mannak *et al.*, 2010; Marchionini, 1989), such as "I like storybooks about lions" or "On the front cover there is a boy and a rhinoceros, and it is red" (Pejtersen, 1986, as cited in Bilal and Bachir, 2007). They often describe a storybook they are interested in by exemplifying the characters or objects that they want to see in the book. Although visualized search interfaces are becoming important (Shiri *et al.*, 2011) and have demonstrated benefits to young children's storybook searching, little is known about how young children use a visualized search interface to search for storybooks. Moreover, as the cognitive development of young children may affect their storybook search behaviour (Schunk, 2004; Cooper, 2002), there is a need to further investigate the difference in the search behaviours of young children of different grades when they use a visualized search interface.

In light of the aforementioned rationale, the purpose of this study is two-fold. The first is to explore how young children interact with a visualized search platform to search for assigned storybooks by assembling the provided visual search items. The second purpose is to explore the difference in visual search behaviours and strategies exhibited by pre-schoolers and second-graders. The results of this study may be of interest to librarians or interface designers attempting to design a specific search interface in line with children's searching propensity and capability.

2. Related literature

2.1 Difficulties in online searching

Young children may have deficiencies in vocabulary, reading capability and query strategies which may create difficulties in generating suitable keywords and browsing abstract categories to search for books in which they may be interested. They may fail to understand many of the particular terms used as subject headings and not be able to recall the appropriate terminology to match the records in a database (Borgman *et al.*, 1995). When browsing through category hierarchies, children may have trouble finding a correct category or may become disoriented in a multi-level abstract hierarchy (Jochmann-Mannak *et al.*, 2010; Hirshh, 1997). In addition, superficial knowledge of query strategies also causes ineffective searches. For example, children seldom exercise Boolean logic skills (Bilal and Kirby, 2002; Reuter and Druin, 2004) and are unlikely to generate keywords beyond the vocabulary that appears in the description of a search task (Shenton and Dixon, 2004; Chen, 1993). Considering young children's difficulties in formulating effective queries, there is a need to assist them in conceptualizing a search plan to locate the targeted information by the use of supportive facilities for searching.

In addition to the difficulties of keyword generation, many technical features of search interfaces requiring proper control of fingers or familiarity with specific interaction metaphors (e.g. file folders for navigation) which also cause problems for young children while searching. For example, typing with a keyboard or pointing with a computer mouse in conventional search interfaces may be difficult for them (Borgman *et al.*, 1995; Gossen and Nürnberger, 2013). Most young children not only have the tendency to type or spell keywords incorrectly (Jochmann-Mannak *et al.*, 2010), but they are also seldom able to identify their typing errors (Gossen and Nürnberger, 2013). Given that conventional search interfaces often adopt metaphors from adults' perspectives and propensities, young children might be unfamiliar with the metaphors used in conventional search interfaces and may have difficulty using the interfaces or will need to learn how to use them (Bruckman and Bandlow, 2002). A touch-based interaction style with an intuitive metaphor (e.g. a storybook cover) would be helpful to facilitate children's interaction with a visualized search interface to perform successful search queries.

2.2 Visualized categories and search tools for children

Many search interfaces provide age-appropriate catalogues or search tools to help young children access physical or digital books. For example, Kid's Catalog (Busey and Doerr, 1993) provides hierarchical graphic categories to help young children select books by navigating the categories without the need to generate search keywords. The Science Library (Hirshh, 1997) has also proposed a subject hierarchy allowing young searchers to navigate among these hierarchical subjects when searching for books.

Instead of using a hierarchical classification, the International Children's Digital Library (ICDL) (Hutchinson *et al.*, 2006) provides a search tool using flat, child-appropriate categories. Young children are allowed to select multiple graphic categories to formulate a Boolean conjunctive query specification. Polajnar *et al.* (2011) introduced JuSe, which adopted pre-defined pictures to represent concrete concepts, such as *cat* or *dog*, instead of an abstract category, such as *animals*. In their study, young children recognized the given pictures and selected pictures to formulate a query. In another children's search interface, TeddIR (Jansen *et al.*, 2010), tangible objects were used to

represent concrete concepts such as *horse* or *car* and then young children put these tangible objects into a "like" or "dislike" box to find books that are relevant or irrelevant to the objects. These search interfaces demonstrate that a small set of visualized concepts in graphic format or as tangible objects, together with intuitive manipulation of these concepts, has the potential to help young children formulate a query regarding storybooks of interest.

2.3 Book selection and search behaviour

When young children select paper books to read, several factors, including the title, characters, cover illustrations or book summaries, influence their selection decision (Swartz and Hendricks, 2000; Kragler and Nolley, 1996; Druin, 2005). Young children tended to look at the front cover first and then checked illustrations inside the book to make their decisions (Wutz and Wedwick, 2005). According to Cunningham (2011), older children also consulted cover images to gain an impression of stories and to consequently aid their memory of previous readings. Therefore, the story's characters, scenes and the colours of the cover play important roles in understanding children's search behaviour and strategies of searching for books.

The findings of paper book searching are akin to previous research on keyword searching. For example, Solomon (1993) explored children's information retrieval behaviour using an online public access catalogue. The findings indicated that the children who grasped concrete concepts, such as *dogs*, were more successful in information retrieval than those who had abstract concepts (e.g. *renaissance weapons*) or others performing searches by natural language queries. In Bilal's (2000) study, seventh-grade students were assigned a fact-based search task using the Yahooligans! site. The author also reported that using a single concrete concept resulted in more hits than did using natural language. Therefore, providing graphic icons serving as visualized concrete concepts may have the potential to help young children formulate concrete concepts in their queries and facilitate an understanding of how young children discover and use concepts for searching in a visualized search interface.

Based on this review, a visualized search interface for young children should consider the nature of children's cognitive and physical development as well as their difficulties with using online search tools. This study proposes a visualized search interface using the metaphor of a storybook cover to help young children intuitively describe the book in which they are interested in terms of thinking about what story elements would appear on the cover. Because young children understand graphic icons better than text (Gossen *et al.*, 2012), iconic interfaces would be more appropriate for children's information retrieval (Maiti *et al.*, 2010). Accordingly, graphic icons used in the visualized search interface may provide young children with concrete concepts about story characters and scenes, as well as allowing them to manipulate the icons to describe and find a storybook cover in which they are interested.

Although many visual search platforms have been proposed in previous studies (Hutchinson *et al.*, 2006; Polajnar *et al.*, 2011), there is little research available regarding the search behaviour and strategies of finding digital storybooks in a visualized environment with young children. Furthermore, exploring how young children of different grades utilize a visualized search interface to search for storybooks of interest may lend insight into the development of more supportive online environments for young researchers.

3. Method

This study used both quantitative and qualitative methods to investigate the use of the visualized search interface with regard to pre-schoolers and second-graders in a search task. The quantitative method aimed to provide data about their search behaviour and performance. The interactions of young children with the proposed visualized search interface were recorded to provide the quantitative data. The qualitative method generated data from interviews with the children. These qualitative data offer an understanding of the search behaviours and processes of the young children's searches for storybooks.

3.1 The visualized search environment

There are many types of visualized search interfaces for young children and they may differ considerably from each other in terms of their influences on search behaviours. This study focuses on the exploration of how young children use the provided visual search items to search for storybooks. To obtain details of young children's visual search behaviours, a visualized search interface was specifically designed and developed in line with the research purposes of this study. As shown in Figure 1, the visualized search interface is divided into three main parts: example storybook cover, menus and search outcome. In the centre of Figure 1 is the editable example storybook cover surrounded by three menus of graphic icons: characters, objects and background colours. The icons of the characters, such as a lion or boy, indicate characters in a story, which often appear in the foreground of a storybook cover and create a strong impression on young readers. The icons of objects or background colours, such as a tree or car, represent important elements of the scenes in a story, which often appear in the background of a storybook cover and help describe the context or environment of the story. The participants could drag-and-drop the graphic icons to edit the contents of the example storybook cover. To specify the characters or scenes in a book, the children

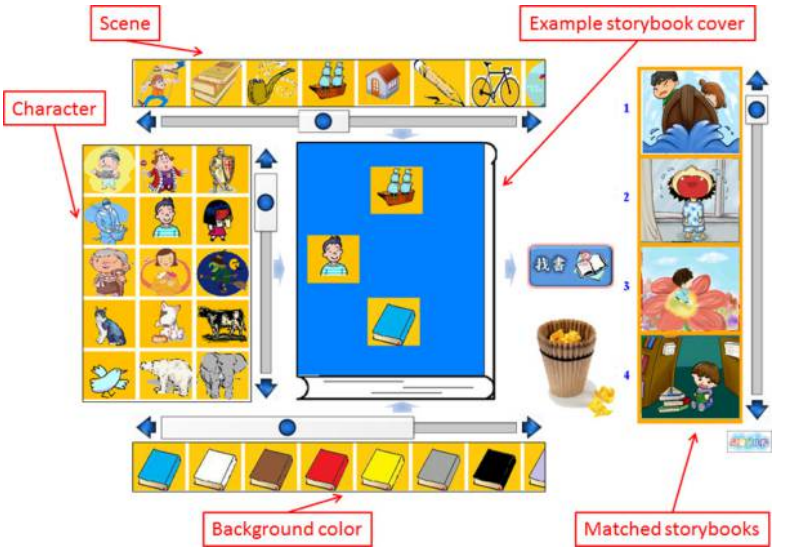

Figure 1.
Assembling an example storybook cover for a search

could select appropriate icons from the character and scene menus. They could also change the background colour of the example storybook cover by selecting graphic icons from the background colour menu below the user-made book cover. To the right of Figure 1 is the search outcome, where recommended matched storybooks based on the contents of the example storybook covers are displayed. If, for example, a child wants to find storybooks about a boy's adventure at sea, he/she first drags-and-drops a boy icon and a ship icon onto the editable example storybook cover. The child then selects the blue colour icon to represent the sea on the cover. The search interface will recommend storybooks that have boys, ships or a blue background on the cover. The child could then choose the book he/she wants by examining the characters, scenes or background colours on the cover of the matched storybooks.

In this study, the visualized search interface included 153 storybooks transformed from the Children's Digital Library in Taiwan (Ministry of Culture, 2006). Among these books, a total of 48 characters, 45 scene objects and nine colour icons were identified and included in the visualized search interface. The data structure used to represent a storybook in the visualized search interface consisted of the title, the cover image, icons, keywords, icon categories and a hyperlink to the book's content. For example, as shown in Figure 2, a digital storybook with forest animals on its cover (selected from Ministry of Culture, 2006) was represented by three characters, one scene and one background colour icon.

3.2 Participants and a search task

The participants were 20 pre-school (12 male and 8 female, aged from 5 to 6 years) students from three kindergartens and 20 second-grade elementary school students (13 male and 7 female, aged from 7 to 8 years) from two different schools in northern Taiwan. All participants were asked to perform a search task which involved searching for three storybooks using the visualized search interface. Table I shows the detailed descriptions of searching for the three books: a favourite, cover-hinted and summary-hinted storybook. According to Bilal's (2002) task taxonomy, the favourite storybook search is an open-ended, fully self-generated search, which imposes the least constraints on the search. This search simulates a condition in which young participants have an intended purpose of finding a favourite storybook. The participants were allowed to freely describe their favourite storybooks in terms of composing their example covers through dragging-and-dropping icons with the visualized search interface. The children could demonstrate their behaviour and strategies of constructing their favourite storybook characters and scenes. The other two searches were relatively close-ended

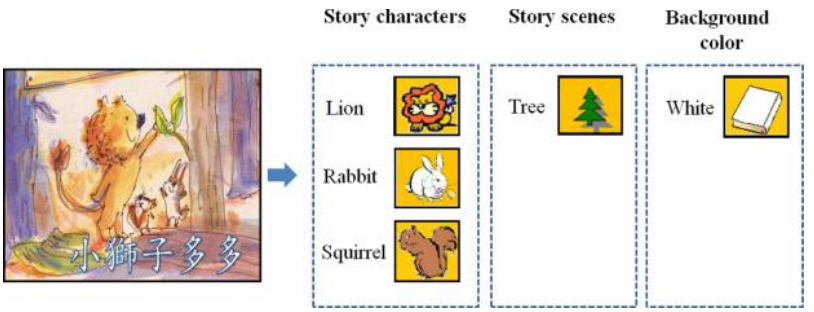

Figure 2.
Icons, keywords, and their categories associated with a digital storybook

Searches	Description
Favourite	Find the storybook you are most interested in
Cover-hinted	Find the storybook whose cover is exactly the same as this one (Ministry of Culture, 2006) 
Summary-hinted	Find a storybook whose story summary is as follows One day, while going on a picnic with their family, a little boy and girl find a lovely stray dog. They want to bring it home, but there are so many difficulties

Table I.
Description of a search task of finding three storybooks

search activities. The cover-hinted search simulated a condition in which the participants had the purpose of finding a storybook for which they already had an image of the cover. This search requires the participants to identify important characters or scenes from the cover to successfully select the target book. The summary-hinted storybook search simulated a condition in which the participants search for a storybook with the guidance of a story summary, from which they are required to recognize important elements. For the cover-hinted and summary-hinted searches, only one book in the visualized search interface fully matched the description provided.

3.3 Procedures

Touch-based computers were used to allow the participants to drag-and-drop icons and perform the search tasks by finger touch. The procedure for the study consisted of training and search sessions for every individual participant. In the training session, an instructor introduced the visualized search interface and encouraged the child to use the interface to search for storybooks. In the search session, the participants were asked to complete the search task (Table I) on the visualized search interface. The instructor explained the process of searching for the three storybooks and ensured that the young participants could understand the purposes of and the requirements for completing each search. During this search session, the graphic icons used and the storybooks selected by the young participants were collected. When the participants finished the composition of an example storybook cover for a storybook search, they were briefly interviewed to investigate their reasons for selecting each icon on the example covers. The participants' responses were recorded and transcribed for later analysis.

3.4 Measurement and data analysis

The pre-schoolers' and second-graders' use of graphic icons, their performance of searching for storybooks and their strategies of discovering concepts for formulating queries were explored and compared. First, to explore their search behaviour, the participants' selection of graphic icons for each example storybook cover was categorized into the pre-defined icon labels of story characters, scene objects and colours. The numbers and categories of icons used by the participants regarding different storybook searches could contribute to the understanding of how pre-schoolers and second-graders use graphic icons to formulate queries and search for storybooks.

Second, their performance of searching for storybooks was explored in terms of total effective icons and overall success of searching for the three storybooks. As mentioned above, every storybook in the visualized search interface was represented with a data structure containing the story's character, scene or background colour icons which appeared on the cover of the book. If a participant used an icon to search for a storybook and that book's data structure contained the identical icon, the icon was deemed to be an effective icon for the search. The total number of effective icons is the number of effective icons a participant generated when searching for the three storybooks, and demonstrates the effectiveness of the queries. Success in the favourite storybook search indicates that a participant identified their favourite book during the search. For the cover-hinted and summary-hinted searches, success indicated that a participant had found and identified the target books. The overall success represents the number of books that a participant successfully found in the search task. The higher number of total effective icons or overall success a young child had, the better search performance he/she was considered to have had.

Finally, to understand the strategies of discovering concepts for formulating queries, in-depth interviews were conducted to investigate the reasons why the children manipulated particular icons to perform the visual search queries. In light of previous findings about young children's keyword searching (Cunningham, 2011; Shenton and Dixon, 2004), the interview responses were analysed along with the dimensions of personal preference, task requirement and association establishment proposed in this study. Two experienced researchers reviewed all transcripts independently to extract representative excerpts containing the reasons why students used one or many particular icons in the visualized search to construct their desired storybooks. The coded excerpts were viewed as meaningful units and then developed into different dimensions relating to the strategies children used for how they formulated concepts to search storybooks. The definition of each dimension with example excerpts was shown in Table II. In the visualized search environment, personal preference and task requirement were used for the analysis to represent strategies of discovering concepts based on personal favourite story elements and the description of a search task, respectively. Therefore, association establishment was also used for the analysis to represent a strategy of discovering concepts by establishing associations among story characters and objects that were not specified in the description of the search task. According to the proposed dimensions, the representative excerpts from the interview responses were identified to represent the children's visual search strategies. An inter-coder reliability analysis using the kappa statistic was performed to determine consistency among coders. The inter-coder reliability was found to be kappa = 0.931 ($p < 0.001$).

4. Results and discussion

4.1 Use of icon categories

As shown in Table III, regarding the favourite storybook search, which was an open-ended, fully self-generated task, the second-graders used fewer character icons ($t = 2.542$, $p = 0.017$), but more scene icons ($t = -3.658$, $p = 0.001$) than the pre-schoolers. This indicates that when visually describing favourite storybooks, the second-graders may apply fewer concepts of story characters, but more concepts from the story scene than the pre-schoolers. During the cover-hint storybook search, the

Strategies	Description	Examples
Personal preference	Discover concepts based on personal preference in story characters, scene objects or colours	"I like the *bat* because it's so cute." (S28) "*Blue* is beautiful." (S30) "Because I like to eat a *cake*." (S3) "Because I want a *king* [. . .] I like a king." (S24)
Task requirement	Discover concepts based on the requirement discovered based on the description of the search task	"The cover has a *lion*." (S5) "It (cover) should be *yellow*." (S6) "Because you said a *boy* and *girl* find a stray *dog* and take it *home*." (S11) "Because there are *trees* on the cover." (S38)
Association establishment	Discover concepts based on the personally established association between story characters, scene objects or colours	"The *king* sits on the *chair* wearing a robe." (S7) "The *deer* and *chicken* are sitting on the *chair*. And the chair has an *umbrella* above it." (S17) "The *dinosaur* and a *dragon* are fighting in the *mountain*." (S39) "Because a family picnic needs *fruit* and *bread*." (S9)

Table II.
Children's strategies for discovering concepts in the searches for storybooks

Use of icons	Pre-schooler[a] M (SD)	Second-grader[b] M (SD)	*t*
Favourite			
Character	3.25 (1.88)	2.05 (0.94)	2.542*
Scene	0.50 (1.00)	1.65 (0.98)	−3.658**
Colour	0.85 (0.48)	1.00 (0)	−1.371
Cover-hinted			
Character	2.40 (0.75)	2.75 (0.63)	−1.584
Scene	0.45 (0.60)	0.90 (0.64)	−2.284*
Colour	0.55 (0.51)	0.95 (0.51)	−2.478*
Summary-hinted			
Character	3.10 (1.61)	3.05 (0.22)	0.137
Scene	0.15 (0.36)	0.40 (0.68)	−1.447
Colour	0.35 (0.74)	0.40 (0.59)	−0.234

Notes: [a]$n = 20$; [b]$n = 20$; *$p < 0.05$; **$p < 0.01$

Table III.
Differences in icon categories between pre-schoolers and second-graders

second-graders used more scene ($t = -2.284$, $p = 0.028$) and colour ($t = -2.478$, $p = 0.018$) icons than the pre-schoolers. No statistical difference was found between the two groups in their use of character icons. This result may suggest that with a clear picture of a story, both the pre-schoolers and second-graders could identify the characters of a storybook and apply the concepts of the characters in the search. However, the second-graders may further identify and apply more concepts of the story scene and background colour than the pre-schoolers. Finally, regarding the

summary-hint search, the second-graders' use of icons regarding the different icon categories showed no difference from the pre-schoolers. This may imply that there is no difference between the second-graders and pre-schoolers in applying concepts of story characters, scene objects and background colours in a search based on the guidance of a story summary.

4.2 Performance of searching for storybooks

Table IV reveals the difference in the performance of searching for storybooks between second-graders and pre-schoolers. As shown in Table IV, both the second-graders and pre-schoolers had high rates of success in searching for the three storybooks. This result may indicate that, with the proposed visualized search interface, all the second-graders and most of the pre-schoolers could successfully find their favourite and the target storybooks. When the two groups are compared, the second-graders achieved higher overall success ($t = -2.629$, $p = 0.017$) and generated more total effective icons ($t = -2.842$, $p = 0.007$) than the pre-schoolers. These results suggest that the second-graders had better search performance than the pre-schoolers did with the visualized search interface. The second-graders may be more capable of applying effective concepts in the visualized search process of formulating queries and be more likely to succeed in searching for storybooks.

4.3 Adoption of strategies for discovering concepts

A series of *t*-tests were used to explore the differences in strategies of discovering concepts between the pre-schoolers and second-graders. As shown in Table V, the second-graders adopted fewer personal preference strategies ($t = 2.571, p = 0.017$) than the pre-schoolers. This result suggests that the second-graders were less likely to generate story-related concepts based on personal favourites than the pre-schoolers were during the visualized process of formulating queries. However, the second-graders used more task requirement ($t = -3.023$, $p = 0.006$) and association establishment strategies ($t = -4.023, p < 0.001$) than the pre-schoolers. This result indicates that when

Performance	Pre-schooler[a] M (SD)	Second-grader[b] M (SD)	*t*
Overall success[c]	2.6 (0.68)	3 (0)	−2.629*
Total effective icons	6.55 (1.57)	7.85 (1.31)	−2.842**

Notes: [a]$n = 20$; [b]$n = 20$; [c]the maximum number of overall success is 3; $*p < 0.05$; $**p < 0.01$

Table IV. Score of overall success and the number of total effective icons in storybook searches

Generation strategies	Pre-schooler[a] M (SD)	Second-grader[b] M (SD)	t
Personal preference	4.8 (5.04)	1.75 (1.65)	2.571*
Task requirement	5.45 (3.3)	7.85 (1.31)	−3.023**
Association establishment	0.75 (1.83)	3.2 (2.02)	−4.023***

Notes: [a]$n = 20$; [b]$n = 20$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Table V. Difference in concept discovery strategies between pre-schoolers and second-graders

generating concepts for searches, the second-graders were more aware of the task requirements and were more likely to create associations among story characters and scene objects.

The Pearson's correlation between the strategies of discovering concepts and search performance was also examined to explore the correlations between the strategies and the performance. The adoption of the personal preference strategy is negatively correlated with overall success ($r = -0.554$, $p < 0.001$). However, the use of the task requirement strategy is positively correlated with the total number of effective icons ($r = 0.607$, $p < 0.001$) and overall success ($r = 0.489$, $p = 0.001$). Finally, the adoption of the association establishment strategy is also positively related to the total number of effective icons ($r = 0.497$, $p = 0.001$) and overall success ($r = 0.324$, $p = 0.042$). These results indicate that the adoption of task requirement and the association establishment strategy tend to have a positive influence on search performance, while the personal preference strategy tends to have a negative influence on overall success.

4.4 Discussion

From an information retrieval perspective, access to specific information involves an information need, formulation of a query and examination of the retrieved results (Baeza-Yates and Ribeiro-Neto, 1999). In this regard, young children who used the visualized search interface to formulate a query to search for storybooks described their information needs by visually making an example of the intended storybook cover, and then evaluated the search outcomes based on the similarity between the outcomes and the example cover. The process of visually formulating a query involves the generation of story-related concepts for a search and the application of the concepts to implement the example storybook covers.

Regarding the generation of story-related concepts, these young children showed variation in adopting the strategies of discovering concepts. The pre-schoolers seemed to be better at discovering concepts from their favourite story characters or scene objects than the second-graders. The second-graders, on the contrary, appeared more likely to discover concepts from task requirements and were more likely to relate concepts from their imaginary story scenes or events than the pre-schoolers. The findings also show that the adoption of strategies for discovering concepts may influence the corresponding search performance. The correlation between strategies of discovering concepts and search performance indicated that the task requirement and association establishment strategies positively correlated with the generation of effective concepts and the search success, while the personal preference strategy negatively correlated with the search success.

Regarding the implementation of example storybook covers, the young children also demonstrated their abilities to select character, object and background colour icons in their visualized search processes. These visualized story-related icons may help young children to address their needs by applying concepts through dragging icons rather than spelling keywords or navigating in an abstract hierarchical category. The results show that young children of different grades revealed different search behaviours in terms of their use of character, scene or colour icons in the favourite and cover-hinted storybook searches (Table III). In the former search, when addressing information needs regarding a favourite storybook, the pre-schoolers tended to mainly use characters and background colours, while the second-graders tended to use characters, scenes and

background colours in their searches. In the latter search, when the children had a clear mental picture of the book's cover as a search requirement, both the pre-schoolers and second-graders could identify and use characters from the picture. However, the second-graders may have further identified and used more objects than the pre-schoolers did. The findings show that the second-graders used the strategy with a more balanced use of character, scene and colour concepts. In contrast, the pre-schoolers tended to mainly apply character concepts to represent their intended storybooks.

5. Conclusions

Considering the difficulties young children may encounter when searching for digital storybooks using traditional search interfaces, this study used a visual search platform to assist young children in searching for storybooks through manipulating the provided visual searching items. Allowing young children to self-select storybooks related to their interests with the proposed visual search interface would be a powerful motivator to encourage young children to take ownership and responsibility for their learning. By examining the activity logs and interview responses of young children of different grades, further comparisons were made to explore their searching strategies, searching performance and information needs while interacting with the visual searching platform. The findings of this study suggest that the visualized search interface offering story-related graphic icons could enable young children to search for digital storybooks by discovering or recognizing story characters, scenes and the background colour of an intended storybook instead of recalling and spelling search keywords.

The study results reveal differences between pre-schoolers and second-graders in concept discovery strategies, icon selection behaviour and search performance. The findings demonstrate that young children in different grades may place different foci on the storybook structure to deal with conditional storybook queries. The pre-schoolers tend to address the characters in the story, whereas second-graders pay more attention to the aspects of scene and colour. The use of story characters, scenes or the background colour icons in the visualized search interface also provides valuable indicators to inform researchers of how pre-schoolers and second-graders formulate their concepts to search for storybooks.

In addition, according to the results of the interview analysis, the children adopt different cognitive strategies to perform visual searching. In contrast to the pre-schoolers performing visual searches by personal preference, the second-graders could exercise visual searching accompanied with relatively high-order thinking (i.e. task requirement and association establishment). Given the differences in the visual searching activity of the young children, future research on the implementation of visual search platforms should consider such individual differences. Furthermore, to support young children's digital storybook searching activities, a visual search interface integrated with specific scaffolds should be designed to facilitate and guide visual searching processes in consideration of all of the principal elements involved in a storybook.

However, this study is only a small-scale investigation. Further work needs to be undertaken with a larger sample and more sophisticated methods to provide robust evidence in other scenarios. In addition to a particular focus in exploring children's visual searching tactics by transforming qualitative data into quantitative indicators, this study suggests that future studies could utilize the methods of in-depth interview to

explore underlying themes in the aspects of learning. Some other alternative qualitative approaches, such as observing on-screen activity of visual searching, could be helpful to enrich our understanding of young children's visual searching patterns. Further investigation is also necessary to explore the integration of the visualized search interface into a reading program, and to explore the effects on reading behaviour and performance. It would also be worthwhile to integrate a peer recommendation function into the search system and to explore the influence of the recommendations on the children's motivation to read storybooks.

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