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A collaborative digital library for children

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Abstract Over the last three years, a digital library interface has been developed where two children can collaborate using multiple mice on a single computer to access multimedia information concerning animals. This technology, *SearchKids*, supports past work in copresent collaborative zoomable interfaces for young children. This paper describes the differences in children's collaborative behaviour and dialogue when using two different software conditions to search for animals in the digital library. In this study, half the children had to 'confirm' their collaborative activities (e.g. both children had to click on a given area to move to that area). The other half used an 'independent' collaboration technique (e.g. just one mouse click allowed the pair to move to that area). The participants in this study were 98 second and third grade children (ages 7–9 year-old) from a suburban public elementary school in Prince George's County, Maryland. The results of the study show distinct differences between conditions in how children discussed their shared goals, collaborative tasks, and what outcomes they had in successfully finding multimedia information in the digital library.

Keywords: Change; Collaboration; Information systems; IT-use; Navigation; Primary; Qualitative

Introduction

Children want access to pictures, videos, or sounds of their favourite animals, space ships, volcanoes, and more. However, young children (ages 5–10 – year-old) are being forced to negotiate digital library interfaces (many times labelled 'Appropriate for K-12 Use') that require complex typing, proper spelling, reading skills, or necessitate an understanding of abstract concepts or content knowledge that are beyond young children's still-developing abilities (Moore & St. George, 1991; Solomon, 1993; Walter *et al*., 1996; Druin *et al*., 2001). In recent years, interfaces to commercial digital libraries have begun to be developed with young children in mind (e.g. Nature: Virtual Serengeti by Grolier Electronic Publishing; A World of Animals by CounterTop Software). However, while these product interfaces may be more graphical, none of these interfaces specifically address collaboration, a critical learning experience for children.

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Structuring collaborative learning experiences has come to be a priority in many classrooms and emphasised by diverse curriculum standards (Chambers & Abrami, 1991; Cohen, 1994; Slavin, 1996; Fulton, 1997; Johnson & Johnson, 1999; Lou *et al*. 2001). However, if one examines the design of today's computers, it is obvious even from the hardware that these technologies often limit children's collaborative interactions. Current computers have been designed with one mouse and one keyboard with the underlying assumption that one person will use the computer. In looking at the literature on computer-supported collaborative learning, the majority of software applications support collaboration only when children 'take turns' using the mouse or when they collaborate from different locations over the Internet (Inkpen *et al.*, 1995; Inkpen *et al*., 1999; Stewart *et al.*, 1999; Wang *et al*., 2001). However, 'Single Display Groupware' (SDG) is an emerging research area that explores innovative technological solutions to support small groups of users collaborating around one shared display (Bricker *et al*., 1998; Hourcade & Bederson, 1999; Inkpen *et al*., 1999; Stewart *et al*., 1999; Benford *et al*., 2000; Stanton *et al*., 2002 (see also Scott *et al*., 2003; and Stanton *et al*., 2003).

Within this focus of research, there have been some initial studies that have compared the use of one mouse to the use of two mice by pairs of children (Inkpen *et al*., 1995; Stewart *et al*., 1999; Stanton *et al*., 2001). In those studies, researchers found that using multiple mice at a single display can motivate users, support more successful problem-solving outcomes, and help focus users on the task (Stanton *et al*., 2001; Stanton *et al.*, 2003). However, researchers did find that shared navigation tasks with the use of multiple mice presented challenges for collaborators. With other tasks, if simultaneous users did not want to collaborate, they could essentially ignore the other person, for example, by drawing on their own side of the screen. However with shared navigation, one child could change the view on the screen making it difficult for the other child to continue their activity of choice (Stanton *et al*., 2001). It is this challenge of shared navigation that is explored in this paper within the framework of a digital library interface for children which was developed.

Method

Participants

The participants in this study were 98 second and third-grade children (ages 7–9 – year-old) from a suburban public elementary school in Prince George's County, Maryland (in the Washington DC metropolitan area). Approximately 52% of the children were Caucasian, 36% were African American, and 22% were Asian or Hispanic. The school serves an economically challenged population of children.

The children were divided into two groups and paired with a classmate of the same gender. The first group, a total of 50 participants, used the 'independent navigation' model for collaboration (as described in the following section on 'The tools and activities'). This group was made up of 24 second graders (14 females and 10 males) and 26 third graders (14 females and 12 males). The second group, a total of 48 participants, used the "confirmation navigation" model for collaboration. This group was made up of 22 second graders (12 females and 10 males) and 26 third graders (14 females and 12 males).

The tools and activities

The children were taken out of their normal classroom and brought to a quiet area in

the school library to take part in the study. Participants used a laptop computer with the digital library application. All of the interface functionality was demonstrated by a researcher, and children were given a free-play period of a few minutes to experiment with clicking on icons to see what happened before the 'treasure hunt' began. Each pair was asked to find as many items as possible from the same paper text list of 20 target animals (e.g. monkey, octopus, etc.). They were asked to put as many of these animals into the treasure chest as possible within a 20-minute session. Each session was videotaped, and a researcher was present to take notes and answer questions. In addition, the software logged all of the mouse clicks for later analysis.

The software the children were asked to use was *SearchKids*, an application developed at the University of Maryland (Hourcade *et al.*, 2000; Druin *et al.*, 2001; Revelle *et al.*, 2002). *SearchKids* is written in Java, and relies on *Jazz* and *MID*, Java toolkits developed in part to support *SearchKids*. Jazz supports the development of zoomable user interfaces (Bederson *et al.*, 2000; Bederson & Boltman, 1999), and MID supports the use of multiple input devices (Hourcade & Bederson, 1999; Stewart *et al.*, 1999; Hourcade *et al.*, 2000). *SearchKids* uses a custom Microsoft Access database that contains the hierarchical metadata with pointers to local files containing the animal-domain content.

Fig. 1. From left to right: SearchKids' initial screen, the zoo, the world and the search areas

The Zoomable User Interface (ZUI) of *SearchKids* gives children a visual, direct manipulation interface to access a digital library of animal media (see Fig. 1). Multiple mice can be plugged into a single computer, and each mouse controls a separate 'hand' cursor. *SearchKids* supports two collaborative interaction styles. The first, 'independent collaboration' enables each child independent control over the interface, so that they can each click on and activate any icon in any location at any time. Each 'mouse click' will change the view on the screen. The second interaction style, 'confirmation collaboration' requires each action to be confirmed by the other child. Therefore, each mouse click must be confirmed by a subsequent click of the other mouse in order to activate icons to change the screen view.

SearchKids has three areas that children can explore: the *world*, *zoo*, and *search area*. Figure 1 shows the prototype's initial screen (left) and the three areas for browsing and searching (right). The *zoo* and *world* areas provide a way to browse a curated subset of the database. To access the full database, children can enter the *search area*, which gives them the ability to graphically specify and manipulate queries (Fig. 1, far right image). It also provides a visual overview of query results, which instantly indicates how many items were found. The primary goal has been to enable children to perform moderately sophisticated queries without any text, but rather by simply clicking on icons. This was done by creating a fixed vocabulary hierarchy of metadata (approximately 25 items), and annotating the database of 500 pictures, sounds, and drawings of animals with it. The metadata hierarchy has four top-level nodes which enable children to search based on what animals eat, where they live, how they move, and what type of animal they are (a biological taxonomy).

Data collection and analysis methods

The first and last five minutes of each video taped session was coded using qualitative techniques for discussion type and frequency. The coding instrument was developed based upon previous coding instruments designed by the team and other collaborators (Bederson & Boltman, 1999; Stanton *et al*., 2002). In addition, the instrument was revised based on its initial use, coding two sample tapes of child pairs. The final instrument and a definition of the codes can be seen in ftp://ftp.cs.umb.edu/pub/hcil/Reports-Abstrcats-Bibliography/2002-07html/2002-07.htm The codes fell into six basic areas: Interaction Style (e.g. explanation, elaboration, new thought), Type of Comment (e.g. agreement, disagreement), Social Interactions (e.g. question, off-topic comment), Task Interaction (e.g. concerning navigating the program, search strategies, animal information) Comment on the Experience (e.g. positive, negative) and Non-verbal Communication (e.g. movement or gesture to the laptop, to a mouse, to the paper). Multiple codes could be used for a given piece of dialogue. These codes were used by five researchers (only one of which was actually present during the video taping) to code the first and last five minutes of each pair's experience. Before coding began all researchers did a pilot-test on the same sample tapes and their codes were compared to look for interrater reliability. There was an average reliability of 81% between coders

Once all tapes were coded, an analysis was done to look for the most frequent kinds of dialogue and the largest differences between conditions. Once these areas were identified, then a content analysis of those areas was done to better understand the specific differences in the children's dialogue. It was at that time that an additional code was added to the analysis based on the data content that emerged. At the same time, an analysis of the data logs was done to examine possible differences in search outcomes. This meant a record of each user's mouse clicks and a listing of the animals found by each pair were analysed. These results were compared with the qualitative analysis of the dialogue to form a descriptive analysis of the children's differences in collaboration.

Results

Frequency Analysis

In examining all codes in all conditions, the four most frequent areas of discussion were introductory, descriptive, task or navigation statements (see Fig. 2). This reflects a consistent pattern of discussion between pairs. Most frequently, the children used an introductory statement to begin a new thought (e.g. '*let's start*' '*time for something new*'). Following this, they often stated what was happening or what they were about to do or look for (e.g. '*there is the elephant*'). Next, they talked about the task (e.g. '*I think it eats meat. Let's go to what it eats*'). Depending on the condition, they would discuss the way they needed to navigate (e.g. '*click here*' '*you click it so wrong*'). Interestingly enough, the frequency of these types of statements

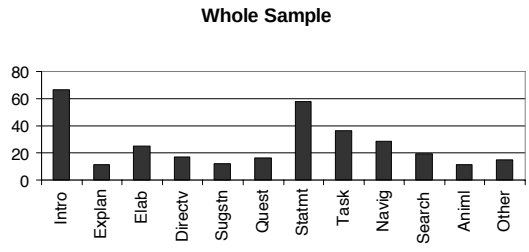

Fig. 2. Frequency of discussion of all 98 children who participated in the study

did not change dramatically over the 20 minute session.

To further understand these frequencies, an examination of the dialogue based on condition showed that the biggest differences in frequency were in discussions of task and navigation (see Fig. 3). Children in the independent condition talked more about the task of finding animals, while the children in the confirmation condition discussed more about navigation issues (e.g. '*you have to click the same time as me*'). It was in these areas that were selected as a focus for understanding content differences (see Content analysis section).

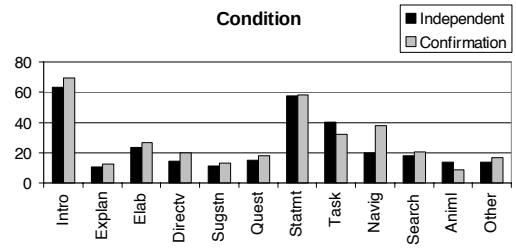

Fig. 3. Frequency of discussion compared by condition

The data were examined to see if there were differences in discussion between the male pairs and the female pairs as well as between grade level pairs. No major differences in the frequency of discussion types based on gender or grade level were found. However, in studying the children by grade and comparing their performance in the two conditions, some differences between the two grades were found when children were discussing tasks and navigation (see Fig. 4). Though both grade-groups spoke more about the task in the independent condition and more about navigation in the confirmation condition, these differences were stronger for the second graders than they were for the third graders, which may suggest some developmental differences between the two age groups.

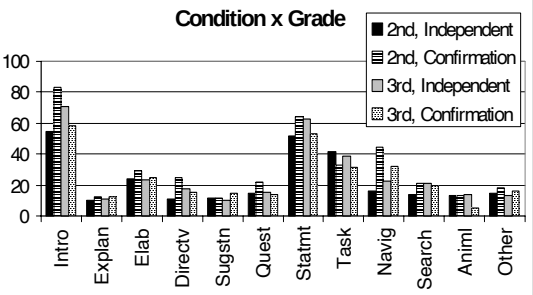

Fig. 4. Frequency of discussion based on condition and grade level

Content analysis

In examining the content of the children's dialogue, two differences by condition were found. The pairs in the confirmation condition spoke more about navigation (e.g. mouse clicks), yet displayed more 'shared goals' in their dialogue (see Fig. 5).

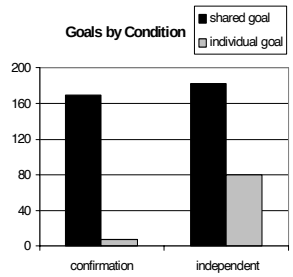

Fig. 5. Total number of shared goals and independent goals by condition

It seems while the constraints of the interface focused the children on the need to navigate, it also kept them focused on their shared goals. In the example which follows, these characteristics are highlighted (Navigation word - ***bold italic***; Shared goal - *italic*) in the conversation of two child participants using the confirmation condition.

Example: females/2nd grade/confirmation condition

D: ***One, two, three…***

T: Let's go! ***You click it so wrong.***

D: Wait. ***Let's count to be able to click.***
D,T: ***One, two, three…***
T: Wait, wait, we've got to wait. Come on!
D: ***Let's do it one time***. Wanna do it?
T: ***One two three***! I wanna go back.
T: No, this one.
D: This one?
T: No, we already picked the one. *Now we gotta pick an animal*.
D: ***One two three***! *What were we looking for***?**
T: Pig!

Under the independent condition where each child could use their mouse to move to an area where he or she wanted, navigation discussions were less frequent. Instead, they seemed to talk more about the task itself. Yet, with this added flexibility, more individual goals emerged in their dialogue. In the example that follows, these characteristics are highlighted (Task word - ***bold italic***; individual goal - *italic*) in the conversation of two child participants using the independent condition.

Example: males/2nd grade/independent condition

W: *Now it's my turn. I want a snake*
M: ***A snake is amphibian.***
M: Ok.
W: ***What they eat?***
M: Oh, wait.
W: No, ***go to the 'eat'.*** We need to get rid of this.
M: We captured it.
W: Okay, ***let's go to what they eat.***
W: *I wanna have reptiles.*
W: ***What they eat?***
M: You want that one?
W: We captured it.
W: ***Ok. Snakes.***
M: ***Where are the snakes?***
W: This one.
M: *It's my turn.*
W: *What do you want?*

Finally, the data was examined to see if there were differences in the total number of shared vs. independent goals based on condition. It was found that there were many more shared goals present in the dialogue in the confirmation condition than in the independent condition. When looking at these goals by gender and grade, there were no obvious differences. What was interesting was that while the difference between the total number of goals was quite clear, the actual variance within each condition was quite different. In the confirmation condition, almost no independent goals were shown in the dialogue. In each case, all pairs show many more shared goals than independent goals. On the other hand, with the independent condition, sometimes the children's dialogue showed an equal number of shared and independent goals, other times, many more independent or shared goals could be seen.

Data Logs

In an analysis of the log data from a previous study (see Revelle *et al*., submitted), it was found that there were differences in how successful the children were in their 'treasure hunt'. There was an interaction between grade and condition. Children who used the independent condition put more 'right' items into the treasure chest, than those in the confirmation condition. However, particularly in the second grade, children in the independent condition put a large number of 'wrong' items into the

treasure chest. As shown in Table 1, 75% of the second graders in the independent condition put four or more wrong items in the chest, and 42% entered nine or more wrong. In fact, second graders in the independent condition averaged placing the same number of wrong items (9.8) in the treasure chest as the number of right items placed there. In that study it was concluded that this result pointed to a developmental difference between the second and third grade pairs in the differential usefulness of the two collaboration conditions. It appears that the second graders need the support of the confirmation condition to help them focus on their searches on the 'right' items, rather than clicking on lots of items with disregard for task goals.

Table 1. Percentage of pairs who had 4 and 9 or more WRONG items in the treasure chest

	3rd grade pairs		2nd grade pairs	
	4 or more wrong	**9 or more wrong**	**4 or more wrong**	**9 or more wrong**
Independent	0.23	0.08	0.75	0.42
Confirmation	0.15	0.15	0.36	0.09

Discussion

What emerged from the data was that there was no clear condition that best supports collaboration. Instead each condition supported certain aspects of collaboration better than the other (see Table 2).

Table 2. A summary of differences between conditions

Differences in…	**Confirmation condition**	**Independent condition**
Goals	Shared goal	Individual goals/shared space
Dialogue	Talked less in general	Talked more in general
	Talked more about Functions	Talked more about Content
Outcome	More focused searches by younger children	Less regard for task goals by younger children

In referring back to the literature on collaboration and learning, many researchers stressed structuring the collaborative experience for better achievement outcomes (e.g. Chambers & Abrami, 1991; Slavin, 1996; Johnson & Johnson, 1999; Lou *et al*., 2001), and in fact this is reflected in this data. The more structured interface that asked both children to confirm their actions, seemed to better support more focused and accurate search results, particularly for the second grade children. It was found that the second grade children who had a more flexible interface with the independent condition seemed to compete for who could click first on a place or icon. This perhaps led to more 'wrong' animals placed in the treasure chest.

In regards to shared negotiated actions, the confirmation condition lent itself to consistently more discussion of shared goals. However, with this condition, the content of the discussions were more functional in nature and less frequent. This suggests that the need to 'confirm clicks' kept the second graders focused on navigation issues instead of task discussion. The children who used the independent condition had more flexible an interface, and were found to talk more about the strategy of finding their animals and less about the 'mouse clicks.' It seems that when there was no need to consider confirming, the younger children could concentrate on the task of looking for animals. On the other hand, in some way, the independent condition was more consistent with the literature that stresses group rewards, but individual accountability (Davidson, 1985; Latane *et al*., 1979; Slavin,

1996). Each child had to be more accountable for their actions; however, this accountability did not lead to better search outcomes. It did however, lead to more discussion about the process, which has made us wonder if these pairs might have learned more about general search strategies and animal content than the other teams who used the confirmation condition.

In general, it seems that there is no a clear-cut 'better' interface for collaborative searching. Each condition offered different strengths that educators may want for their classroom teaching. If educators are interested in stressing shared negotiated action, then the less flexible interface for children may be more appropriate. On the other hand, if educators are interested in stressing the quality of the communication and process, making children more accountable for their actions, than the more flexible interface may be appropriate. In regards to search outcome however, educators might consider a less flexible interface condition.

Conclusions

This study shows that different interfaces may be more appropriate in supporting different aspects of children's collaboration experience. For educators, it is critical that they understand that there are trade-offs in what different technologies can support. The learning outcomes they are striving for should dictate what technologies are appropriate for use in the classroom.

In regard to designing new collaborative technologies for children, it appears that interfaces that enforce collaboration, may only be supportive of some learning experiences. On the other hand, non–enforced collaborative interfaces may better be able to support the process of collaboration, but not necessarily the outcomes. This may mean that technologies need to be designed that have options for both conditions of collaboration in a classroom.

In considering the limitations of this research, it is necessary to do future studies that compare what children have learned about searching with their process outcomes. Due to the exploratory nature of this study, it was possible to describe some of the complexities concerning which aspects of collaboration may be better supported by different interfaces, but it is hard to generalize from these qualitative research findings without further targeted quantitative studies.

Therefore, future research plans include not only further evaluation of digital libraries technologies, but further development of the interface to support various collaborative behaviours. The search content area will be expanded to include digital books about many topic areas. It is thought that this will lead to future challenges for interface design, and even more possibilities for exploring collaboration activities for learning.

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