D2.1 Collaborative interaction models/interfaces

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Abstract	In this deliverable we will describe collaborative interaction models and interfaces which are targeting at how collaborative search interfaces can be used to support known difficulties in children's interaction. This deliverable is the outcome of Task 2.1, targeting the development of new interfaces that encourage and support collaborative search interaction by child searchers. The report on user requirements and scenarios (D1.2) has been taken into account and we will refer to selected scenarios to show how the models and interfaces developed in WP2 can provide suitable solutions for various settings.

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Executive Summary

Children naturally interact with each other and collaboration is encouraged as part of children's social development. Cooperative search systems using community search information (previous queries, search patterns, etc.) have been shown to be very effective in supporting adult searchers. Children, however, often collaborate differently than adults. They also collaborate differently at different ages: younger children are more likely to display egoistical behaviour than older children, for instance. Research is needed on how collaborative search interfaces can be used to support known difficulties in children's interaction. In this deliverable we will describe collaborative interaction models and interfaces which are targeting these issues. This is part of the outcome of Task 2.1 (Collaborative search interfaces), targeting the development of new interfaces that encourage and support collaborative search interaction by child searchers. The report on user requirements and scenarios (D1.2, completed in 2009) has been taken into account and we will refer to selected scenarios to show how the models and interfaces developed in WP2 can provide suitable solutions for various settings.

1   Introduction

Collaborative activities of children take place in many situations. Sometimes it is explicitly planned, for example as part of a learning activity in the classroom, but very often it happens implicitly as an unplanned action, for instance during a game when a child discovers that he/she cannot solve a task on its own. However, there is a long tradition of academic dispute about the ability of young children to learn collaboratively. Over the last decades there have been several objections by developmental psychologists that pre-school children in particular lack certain cognitive prerequisites for effective collaboration (Daiute, 1985 and Gauvain & Rogoff, 1989). On the other hand there are examples of research in computer supported collaborative learning for children which show that even very young children can benefit from collaborative settings (Lingnau, Hoppe, & Mannhaupt, 2003). Nevertheless, the key to achieve engaging children into successful collaboration is the orchestration of the setting in which collaboration should take place (Crook, 1998). Crook summarised different viewpoints and findings and concludes that "we must consider more carefully the settings in which collaborations are organized". Crook identifies two potent forms of mediation of collaboration which addresses even children in Kindergarten and pre-school. "The first is a jointly visible and manipulable array of playthings" (Crook, 1998) since it has been shown by various studies that even very young children and toddlers showed an "active concern for developing shared reference in relation to a set of interesting objects accessible between them".

The second form of collaboration mediation described by Crook can be summarised as implicit or explicit scripting of the expected collaborative activities. Free collaboration very often does not lead to the expected results. Moreover, it is likely to be completely useless and ineffective (Dillenbourg, 2002).

In PuppyIR we want to foster collaborative search in situations where it does make sense that children work in pairs or groups. PuppyIR will provide new forms of collaboration in the context of IR which will be researched and evaluated to improve the possibilities of children using IR technology. Some of these situations are highly related to the process of learning; others are more related to general information search and entertainment. To achieve the goal of building a successful scenario of collaborative information retrieval for children we will carefully combine suitable hardware and software (see section 3.1).

In this deliverable we will describe collaborative interaction models and interfaces to support children in jointly searching for information. We will give an overview of requirements and existing design patterns of user interfaces for children and present different sharable interfaces which are suitable for our target group. In section 2 we will describe our model in detail before we outline a sample of potential use case scenarios or implementations.

1.1 Sharable interfaces

Sharable interfaces are bearing a high potential for the design of innovative computer supported learning and working scenarios in professional development, academic education and learning context in schools. (Streitz, et al., 1999, Ishii & Ullmer, 1997, and Hoppe, Lingnau, Tewissen, Machado, Paiva, & Prada, 2007) . In PuppyIR, we will use sharable interfaces to enable children to become engaged in joint activities of information search and benefit from each other's contributions. Thereby, information could be either shared directly by using large interactive devices which support multiple user activities or by using single user interfaces in conjunction with appropriate software which allows for sharing activities and information. Our focus for the collaborative interaction model will not be limited to multi-touch and tabletop devices. The model will also take into account the potential of single user interfaces and mobile devices as possibilities to share information and enable children to collaborate. For the design of collaborative interaction models we will deal with different types of collaborative interaction for

children which have been identified as potentially useful in the context of information retrieval. Table 1 gives an overview of the different types of interactions the collaborative interaction model will address.

Table 1 Overview of collaborative interaction types

Category	Label	Description
Queries	Pre-literate/literate queries	Queries either by **pre-literate** children using only non-textual objects, e.g. images, physical objects, tangibles vs. queries by **literate** children with basic or extended reading or writing skills. The latter does not necessarily mean that children will be able to formulate textual queries and read complex textual information but they can read and write short sentences and they are able to extract the meaning of short stories or basic instructions.
Activities	Shared / synchronous / asynchronous search activities	**Shared** searches take place on one device accessible by more than one user at the same time, e.g. a large multi-touch table; shared collaboration is per-se a synchronous activity. **Synchronous** searches can also take place using shared workspaces with multiple devices, whereas **asynchronous** search can happen either as a sequence of searches by multiple users on the same device or by multiple users in a distributed environment at different times.
Ability	Capable / incapable collaborators	**Capable** collaborators are children of an age where they can cope with collaborative tasks by just following a vocal task description and act in a self-motivated way without the need of additional guidance. In contrast **incapable** collaborators will need implicit or explicit scripting to be able to work successfully on a collaborative task.
Mode	Physical / virtual collaborators	**Physical** collaboration will take place when children act together either on the same device (shared) or synchronously but in the same location, e.g. using a shared workspace on two or more devices in a face-to-face situation (tablet pc, mobile phone, PDA, …). **Virtual** collaborators are usually non-present, but can either participate synchronously or asynchronously.

Depending on the scenario, the categories can change over the timeline of a task. For example, in a museum, a school class of 3rd graders might initiate a search activity using an interactive multi-touch/multi-user device. After coming home, some pupils will continue this activity on their own computers at home. On the next day the teacher decides to work again on this task using the school's computer room where every child works separately on his/her own computer instead of using a multi-user interface. Referring to the categories in table 1, this will lead to the collaborative interaction types shown in Table 2.

Table 2 Example of collaborative interaction type changes

	Queries	Activities	Ability	Mode
Museum	Literate	Shared	Capable	Physical
Home	Literate	Asynchronous	Capable	Virtual
School	Literate	Synchronous	Capable	Physical

In the hospital scenario, described in D1.2 (2009), a search will be initiated by children at different times and places, but, with PuppyIR, they find that they are interested in the same topics and continue their search activities as virtual collaborators. Finally, after being home and having recovered, a child wants to share information about his/her disease with his/her classmates, and

the teacher decides that the group should work on this task together. Analogue to the example above, this task will change over the timeline as shown in Table 3.

Table 3 Example of collaborative interaction type changes in a hospital scenario

	Queries	Activities	Ability	Mode
Hospital (start)	Literate	Asynchronous	Capable	Virtual
Hospital (joint)	Literate	Synchronous	Capable	Virtual
School	Literate	Synchronous	Capable	Physical

2   Collaborative search model

In the PuppyIR project we not only aim at providing children with adequate search interfaces and sophisticated result presentation. Since we expect that PuppyIR systems will be offered to children in various everyday situations, many of them will include the potential for collaboration. Apart from learning situations in schools where collaborative settings without computers already play an important role in the pedagogical concept, explicit or implicit collaboration and cooperation takes place in many other situations and strengthens the ability to solve problems and to communicate (Slavin, 1999).

Nevertheless, in certain situations children tend to separate from a group to follow their own interests and avoid the need to share things they do not like to give away or they have a lack of motivation. Motivation is an important aspect and the collaborative design model in PuppyIR tries to take this into account. Intrinsic motivation can be explained by two determinants: a task performance which leads to a sense of mastery and competence, and a novelty which leads to a sense of curiosity, attention, and interest (Reeve, 1989).

For the children themselves it is extremely important that they get an answer to the question why they should collaborate with others. Thus, it is imperative that children realise the benefits they get from collaborative search interfaces to motivate them and keep them in a flow experience (Csikszentmihaly, 1991). Flow experience, often applied in the context of gaming (Chen, 2007), is defined as an optimum between the challenges posed to the user and abilities of the user (Csikszentmihaly, 1991). Hence, personalization, difficulty, and interest/enjoyment are key issues.

2.1   General overview

Children discover interesting things in many situations. Apart from subjects and lessons in school the need for further information about a special topic or item can evolve from many opportunities. A school excursion, a trip to a museum, a visit to the zoo, a walk through a forest or a holiday in a foreign place or just playing with friends can always become an opportunity to pick up a new topic a child would like to know more about. To enable children to use an information interface, these personal "experiences" must be sampled from the physical world and made available in the digital world. To avoid that children are distracted in their search for information the barriers for the change from physical to digital media needs special attention.

Figure 1 shows a general overview of the interaction model where children sample experiences from outside and use them as search items in an information interface. Children's "experiences" can be sampled in different ways, e.g. by using a mobile phone, PDA or digital camera to gather snap-shots of interesting objects using image recognition to invent a search[1] or by using a ticket with a special unique bar-code ID in a museum where bar code scanners are provided at exhibition artefacts to register personal interest in a special object. Furthermore, in other contexts for example toys or puppet dolls may be used as tangible objects representing topics, keywords or generally new experiences the child likes to bring to use and which allow for requesting further information at a suitable interface.

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[1] See http://www.google.com/mobile/goggles
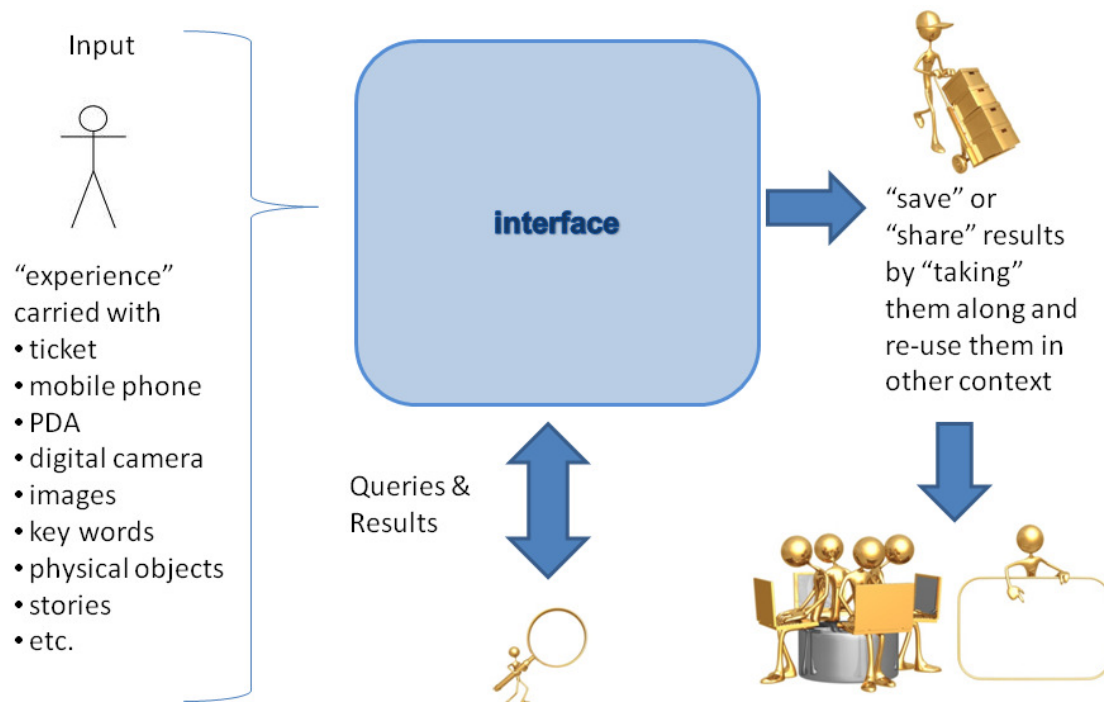
Figure 1 Interaction model overview

When the child wants to finish using the collaborative interface, it is an important aspect that the accomplished results are not lost. Re-usability and the option to share results at a later point in time are important issues the model will take into account. When a child leaves the search interface the results will be stored and can be used again at the same device or in a different setting, alone or in a group again. Thus, working with PuppyIR will provide children with an ongoing experience of interaction and information retrieval which is not limited to a specific time interval spend on one session. In the following sections we will give a more detailed description of the PuppyIR collaborative interaction model.

2.2 Adaptivity and individualisation

Adaptivity and individualisation are powerful mechanisms to ease the access to interaction interfaces, not only for children. Dedicated user models which either get basic input from the users themselves or sample information during interaction processes can help providing individualisation and adaptivity (McTear, 1993). Our main target currently is on how to support collaborative search interactions for young children (see section 3.1). Children's abilities and cognitive levels vary related to their age and cognitive development. Older children are likely to decide on their own whether they want to filter information during an interactive search, for instance by enabling or disabling options or adding further keywords. In contrast, younger children or children with special needs will need an interface which presents carefully pre-selected results without overloading them with information. To avoid that simplified access leads to less availability of information and poorer results, the interface needs to both guide the children and enable them to navigate their search into different directions.

For example, the collaborative interaction interface in PuppyIR will support different ways for children to enter their individual interests and individualise interaction for information search about their topics of interest. Figure 2 shows different kinds of experiences children are entering to a sharable search interface. The list of individual objects used for the aggregated start screen is not limited to the items listed in the model. The idea behind this model is that children can use

different technologies and gadgets to transfer experiences from the physical world to the digital world and use these experiences as initial items to define their topics of interest. Referring to Table 1 this will enable children of both abilities, pre-literate and literate to instantiate initial queries and start a collaborative, interactive search.
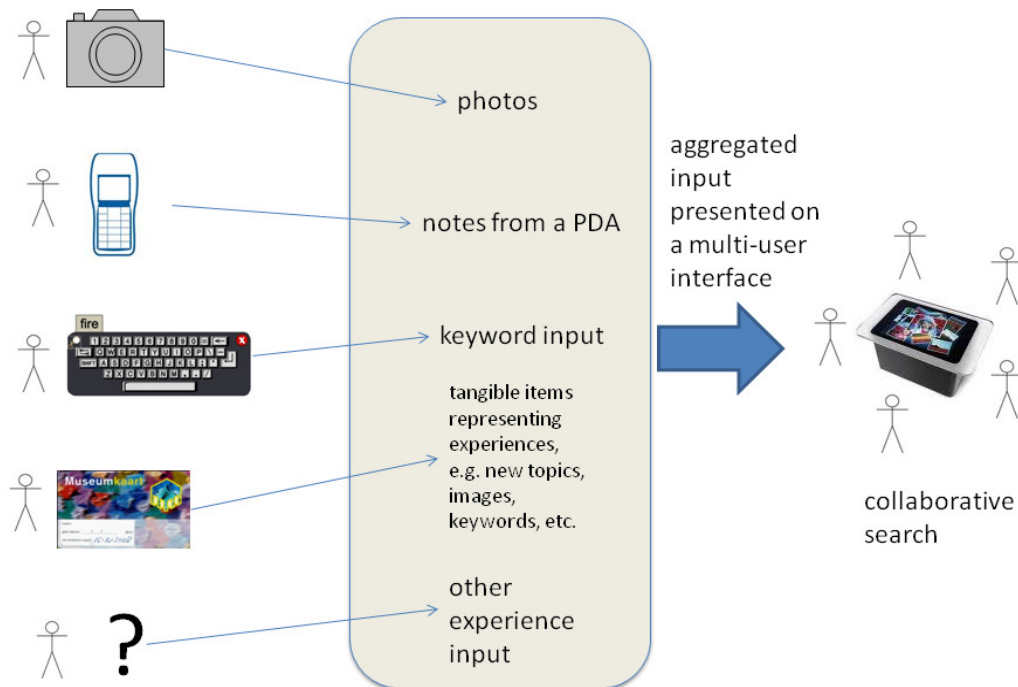
Figure 2 Model of children's experiences as initialisation for a collaborative search

In Table 1 we presented different kinds of interaction types, we will focus on when designing collaborative interfaces in PuppyIR. In the model we present in Figure 2 we are using a multi-touch table as one possible interactive device which provides collaborative interaction. Referring to the collaborative interaction types in Table 1, here we target at supporting shared activities in physical collaboration which suits both capable and incapable collaborators. As a baseline idea for the instantiation of a new collaborative search activity for these target groups, the input will be aggregated and main topics will be identified to avoid that the information provided to start a search is too complex and leads to an information overload. The concrete realisation depends on the particular interface where the collaborative interaction model is implemented. This will help the children to initiate a collaborative search by deciding on the topic they would like to focus on in a first step. By analysing the different experiences children bring to the interface, preferences will be identified and the potential main topics will be presented for selection. After the children start to search for information and continue to make further decisions on what they want to explore and which information can be removed, a history function will provide the possibility to step back to previous views or recall some of the results individual children have been interested in, but have been overruled by the others. In the following section we will discuss a possible way to let children express their individual interests during a collaborative search and implicitly script the task.

2.3 Scenario dependant implementation

As described in Table 1, different interaction types can be identified for collaborative search activities. To implement a collaborative interaction model for a concrete scenario there are different stages in the implementation process which should be passed. The identification and categorisation of task dependant interaction types can help to analyse the demands of a concrete scenario. In WP 2 we will continue to further elaborate the different categories of interaction types and prepare guidelines for developers to analyse requirements to improve the implementation of interactive collaborative search interfaces using the PuppyIR framework.

3   Children & Interaction

3.1 Stimulating collaboration

As described by Crook (1998), engaging young children in collaborative tasks requires a well elaborated blend of hardware, software, content material and mechanisms to guide children though the task. Particularly scripting the task is of high importance. Just offering the possibility of free collaboration to children does not systematically lead to successful results. "The pupils were concerned about getting pieces of information quickly from their peers rather than sharing experiences and coordinating their efforts with them" (Alexandersson & Limberg, 2003). In fact free collaboration can be completely useless (Dillenbourg, 2002). To improve the outcome of collaboration, Dillenbourg suggests dismantling the concept of script by reifying it into the interface itself. In our model we will follow this approach to avoid the need to narratively script the collaborative tasks, i.e. that an adult needs to explain a task step-by-step and continuously intervene while children try to work collaboratively. Instead, children should be enabled to collaborate and manage a task on their own. Therefore we are researching mechanisms to implicitly script and stimulate the collaboration and try to help and support the children on organising themselves without interfering the workflow.

To realise implicitly scripted collaborative search tasks for different scenarios we will set-up a list of potential design patterns for scripting collaborative search and evaluate them in our prototypes. One potential design pattern we identified targets to foster team building. It can be described as a non-exclusive mode on multi-user/multi-touch interfaces, where in a game-like approach at least two "players" are needed to initiate the interface by sharing experiences (for instance, by submitting images or placing a tangible object on a table) before they can continue.

A second potential design pattern aims at fostering collaborative decision making. Children get an initial amount of virtual tokens. For each topic, tokens can be placed to express interest in this topic. Tokens will probably have different values. Items which get tokens from one child only are intended to be stored in private workspaces whereas items with tokens from two or more children will be used in shared activities.

These design patterns will be extended and evaluated in further prototypes and user studies.

3.2 Private and shared workspaces

Even in collaborative settings, private workspaces can make sense to provide children with additional functionality outside of the shared activities (Avouris, Margaritis, Komis, Saez, & Meléndez, 2003). If "experiences" brought from the outside physical world first appear in a private workspace, the child gets the freedom to decide whether everything should be shared with other children and used for further search in a phase of review in a private workspace. It can also be used by children to mark results from collaboration and store them in a private workspace where they can be re-used, for example to watch a movie again or in full length at home. To avoid too much cognitive load caused by extensive need of managing data, the concept of private workspaces within shared environments will be considered carefully and researched in some experimental settings to make sure that they are only recommended to be used with children if they are benefitting from it and are not been overloaded with information management needs. Another possibility can also be to use private workspaces in the background and fill them automatically with content during a collaborative search session and only visualise the content when the child accesses the results from home with an individual ID.

3.3 Re-use of information

Re-usability of data and learning objects is an important aspect in the design of learning environments (Koper, 2003) but not limited to learning only. PuppyIR will support reusability of data in interactive search interfaces. We identified two main aspects as important:

- Re-use of data from previous search, e.g. on the same device with other pupils in a public place (museum, etc.).
- Re-use of data at another location by the same children, i.e. when a school class wants to re-use sources in the classroom formerly discovered, e.g. in a museum, or if a child wants to re-use sources from a collaborative search at home.

Figure 3 shows the possible data flow in a collaborative search model. New collaborations may be initialised by experiences only or by including data from former searches. Results are stored in a shared memory and can be accessed by the participants again within either a shared or a private workspace. In addition private data storage allows for further investigation of information which has been abolished by the whole group. Permanently abolished results may indicate that there is no interest in similar information which can influence further information retrieval.
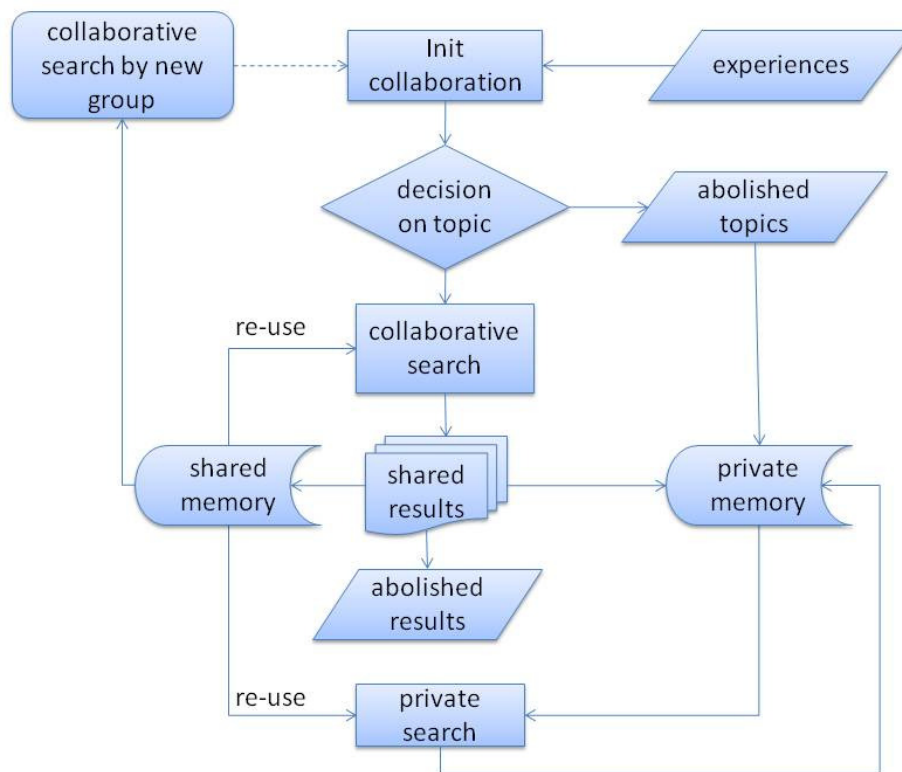
Figure 3 Data flow in shared and private workspaces

3.4 Children's interaction requirements

It cannot be taken for granted that children who can solve a specific kind of problem in one domain are necessarily able to transfer that skill to a different domain. Furthermore, it is controversial; age dependant and design related if children are better performing using drag & drop or point & click (Gelderblom & Kotzé, 2009). Thus, for the design of collaborative interfaces in PuppyIR it is essential to study the performance of children while composing search queries, using multi-modal interaction methods on multi- or single-touch, pen- or mouse-based hardware.

This will enable us to define intuitive ways of interaction and provide children with easy to use interfaces without the need of learning special commands, interactions or gestures.

We aim at identifying intuitive interaction patterns of children while collaboratively working with multiple virtual and tangible objects on different hardware interfaces. Furthermore we will investigate in how far children may have difficulties in combining virtual and tangible representations. Mixed models of real and virtual can cause cognitive problems (Uttal, Scudder, & DeLoache, 1997), particularly for very young children, since they are not necessarily able to infer the same correspondence metaphor between literal and symbolic meaning in tangible environments as older children or adults (Price & Falcao, 2009).

To reach this goal, in a first step we carried out a series of pre-studies with pupils in the age range of second and third grade (aged 7 to 10). Here we tested different interaction patterns, e.g. resizing images using two fingers or turning objects around on dual- or multi-touch devices. The results of the pre-studies will influence the further design of the interfaces and models and will be published in scientific context together with results from more elaborated user studies.

3.5 Interface techniques

In PuppyIR we aim at designing interfaces that are suitable for children of different age, and with different abilities and skills. Children usually have different experiences with computers and so called modern electronic gadgets like smart phones and MP3 players. There are already well established ways of interaction with pen-, single- and multi-touch devices which are mainly designed with adult users in mind. In this section we will present the most common ones and discuss positive and negative aspects of these techniques particularly for non-adult users.

3.5.1 Lasso selection

Selecting different objects in a graphical environment using a lasso function is one method which is often provided by image editing tools like Photoshop etc. It allows for selecting unshaped forms by drawing a lasso around, marking the selected area. Using this functionality for a selection of single objects means that all objects within the lasso-area would be selected as a group of objects. This interaction method can be used with all kinds of interfaces, i.e. single- or multi-touch, pen, mouse, or finger based input. It is a very flexible technique concerning different kinds of objects, since images, tangibles, and text boxes can be selected with one interaction. Furthermore, selections can be done without the need of a special display area, so particularly on small displays space can be used more effectively. Switching to a special selection mode is not required and on multi-touch devices more than one selection can be made at the same time. There are also some problems with the lasso paradigm. One is that on touch interfaces users need highly developed fine motor skills and a general understanding of how to draw a lasso around objects which are not located close by. Finally, in multi-touch environments one user can get in the way of another if they try to select the same object. Referring to Table 1 this interaction method is particularly useful for shared activities, but since first tests in our pre-study showed that children aged 7 to 9 have problems selecting multiple objects in just one interaction this method is likely to be applicable for older children only.

3.5.2 Selection by point & click

When using a mouse as an input device, (Inkpen, 2001) found that some pupils perform much better using point & click techniques rather than drag & drop. These findings are the result of a study where no direct interaction via finger or pen was possible, so it does not take into account the differences between direct manipulation with finger or pen versus indirect mouse-based manipulation. In contrast (Hourcade, Bederson, Druin, & Guimbretiere, 2004) found that the difference between the performance of children aged four and five and older children or adults is large enough to warrant user interface interactions designed specifically for preschool children, which compared to older pupils do perform less successfully when using mouse based interaction devices.

The advantage of point & click is that, once implemented, it can be used with all kinds of devices (single, multi-touch, pen-, mouse-, or finger-based) and children do not need fine motor skills, since particularly users with special needs and physical disabilities can use special input devices like track-balls. By highlighting, selections can be made without the need of a special display area, i.e. particularly on small screens, space can be used more effectively. Furthermore, selections are easy to understand because of immediate feedback when pointed objects are highlighted. However, this selection method is not flexible concerning all kinds of objects and devices. Tangibles cannot be selected by finger-based point & click and in multi-touch environments different selections at the same time cannot be allocated to different users or groups of objects. Thus, formulating more than one query at the same time is impossible. Referring to Table 1 this interaction method can be used in all kind of activities, abilities and modes.

3.5.3 Selection by virtual collection

Instead of highlighting or marking different kinds of objects like images, text or tangibles, a virtual collection picks up the idea of a shopping basket where relevant objects are virtually stored to form a group which can be used for further processing. Among other things, this concept is found in on-line shops where the user browses around and selects different items he/she wants to buy. Selections can be done either by drag & drop or point & click. Before a transaction is finally finished, the shopping basket is presented again to the user. The user can decide to delete items from the basket, go back and continue shopping or check-out and pay.

Translating this principle to search queries will offer the children the possibility to pick items they are interested in and place them in a *virtual basket*. Before they finally invoke a search they will get a summary of the collected items. They can decide to delete items, go back and refine the content or retrieve the search results. This principle is ideal to be combined with additional technology like a personal identification tag using tangible objects, bar codes or whatever technology suits best in a special scenario. Virtual collections can be used in conjunction with all kinds of input (single- and multi-touch, pen-, mouse-, or finger-based hardware) and even with embedded devices like barcode scanner, mobile phones, PDAs etc. Depending on how items can be selected, children do not even need fine motor skills, which make this maybe the most accessible way of composing a query.

In multi-touch environments, different selections at the same time can be realised with multiple virtual baskets which will allow for more than one query at the same time. Since a virtual basket does not need to be visible all the time, space on the desktop can be used in a very effective way. A further advantage of this technique is that older children may be familiar with these principles since they are likely to have used on-line shops before with their parents, e.g. to download music, an e-book or an audio-book.

However, putting tangibles into the basket could cause problems and needs a special interaction paradigm, e.g. a visualisation of a basket on the screen, where the tangibles have to be moved to once. In a multi-touch environment one user could get in the way of another while selecting objects at the same time and probably the virtual selection causes cognitive problems for younger children, since selected objects are not visible all the time, and a permanent display area may be very small, at least on small screens. Thus, referring to Table 1, virtual collections are less suitable for shared activities but can be used in synchronous and asynchronous activities. In both cases, they represent "virtual folders" which might be inspected by other users, merged or copied and thereby are applicable to advance collaboration between children. This is also true for section 3.5.4.

3.5.4 Selection by positioning

Without doubt, positioning objects on a screen is a very intuitive way of sorting or grouping items. Disregarding the screen size it can be realised very easy and is an alternative version of the

virtual basket idea. Instead of placing items into a virtual basket which may be presented on request only, here objects are moved to a special permanent display area on the desktop which represents the selection and therefore the query. To avoid the waste of space on the screen, images and text keywords could be minimized optionally.

3.5.5 Summary

In this section we listed and discussed some of the most common interaction methods and design paradigms widely used in current interface design. Since they are mainly targeting adult users, in the interface design for PuppyIR we will carefully use these techniques and try to find ways to adapt them to the special needs of young computer users. Despite the fact that the hand-eye coordination may be easier using pen or finger based input instead of mouse-based input devices, the PuppyIR interface design will carefully take these findings into account to provide also suitable interfaces for older children and mouse based devices. Since the open source environment has to address different user needs and various input devices, different techniques will be implemented if necessary to achieve the goal of providing appropriate interaction mechanisms for children. We will also try new ways to provide children with interaction methods to enable them to work independently and self-directed and minimise outside intervention.

4   Example of a use case scenario

In D1.2 (Report on user requirements and scenarios, 2009), user requirements and scenarios have been reported which made an impact on the design and modelling process described in this deliverable. Following the recommendations of the first annual project review and internal discussions we are mainly focussing on two scenarios described in D1.2. In this deliverable we describe how we will promote interfaces rather than fully specify them. Apart from the general demonstrators which will be developed as one main final outcome of PuppyIR, we will also design smaller, scalable scenarios. In the following section we will exemplify scenario 2 (Museum) from D1.2 as one of these scenarios which is currently implemented the furthest.

Within Museon, a multi-touch table application is currently under development, through which children can collaboratively select a route through the museum based on their interests. This route is presented in the form of a quest, where children have to answer a question at each exhibit before being instructed towards the next exhibit. To support the quest, a touch screen is placed near each exhibit. The quest ends at the multi-touch table again, where the children are supported with a game to evaluate what they've seen.

During their way through the exhibition, the different experiences children make while moving from one exhibit to another, the ticket will carry their experiences by being linked to exhibits through a bar-code scan. Back at the multi-touch table, the ticket can be placed on the table and enable the child to access the experiences.

An example of a current museum visit is given in Figure 4. This figure perfectly illustrates why there is a need for guidance to optimize the museum going experience: children tend to go through the museum in an unstructured manner, thereby missing out on a large part of the museum and getting many incoherent pieces of information.
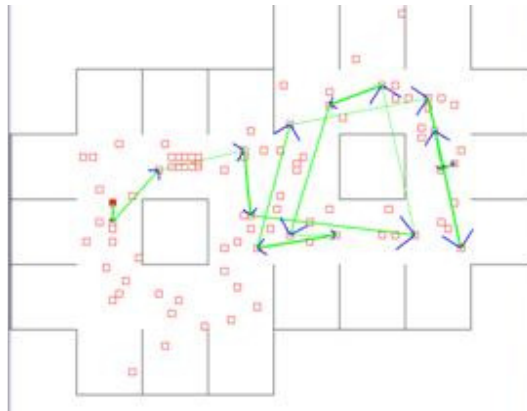
Figure 4: Example museum going experience.

Collaboration is introduced at the multi-touch table; i.e., at the beginning and end of the quest, for groups consisting of 2 to 4 children. The collaboration is, as suggested in this deliverable, in a scripted way: the table shows how the children need to choose interesting categories, whereas after the quest the table presents a game guiding the children in a collaborative evaluation of the received information.
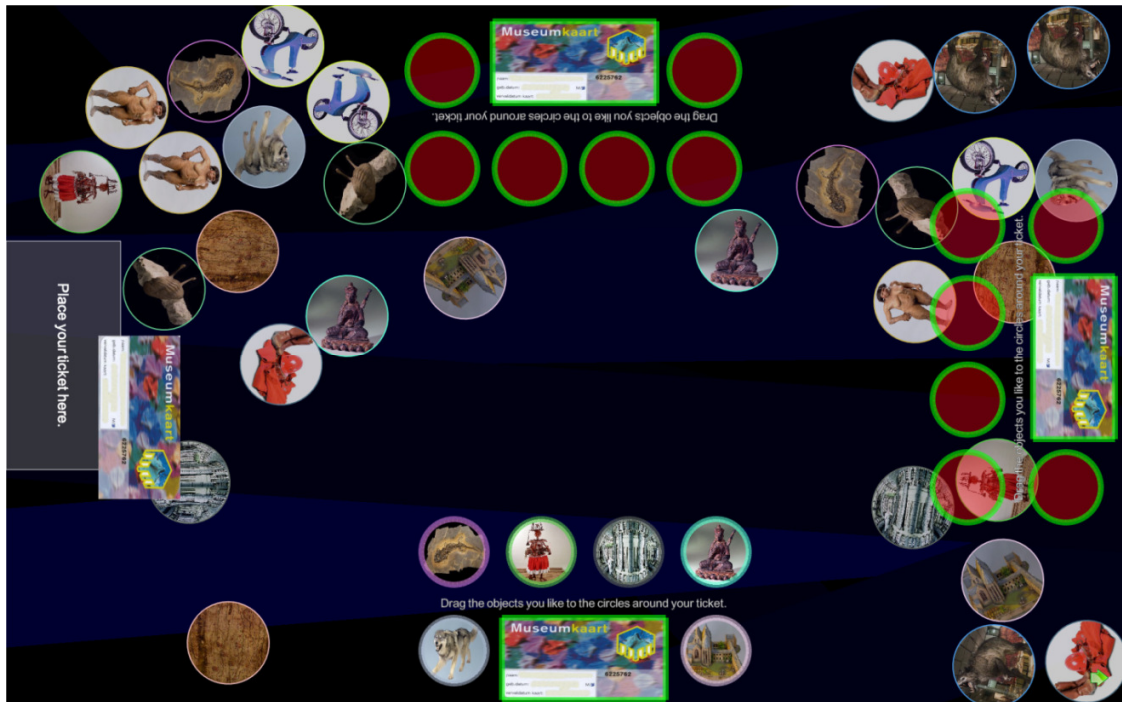
Figure 5: Collaborative selecting of interests

Figure 5 contains a screenshot showing how children select categories according to their interests. In the initial phase the available topics are represented by round images. To ensure that all children have access to the full range of topics, every single topic is represented four times but can only be selected once by every child. Therefore images (representing interests) on the table are moved into their personal "buckets". The collaboration is physical, synchronous, and shared: children share one device at one moment and one location. During the quest the collaboration is neither shared nor physical, but is still synchronous: each child performs a personalized quest, near to and interacting with the other children. This process is in accordance with the flow chart in Figure 3. A search is initiated at the table, a guided decision is made on the topic(s), after which the actual collaborative search is performed (i.e. the quest). In the end, the results are shared again using the game.

The objective of this collaborative, personalized, and adaptive quest is to enhance the museum going experience, particularly to enhance the enjoyment and educational value of the museum going experience. As such, this is an example of how key values of PuppyIR can be used to enhance motivation and experience, and with that the use of the information by the children performing a search.

5   Action Analysis & Evaluation Support

There are many aspects within collaborative search scenarios for children which have to be evaluated. Within WP5 generic evaluation methodologies will be developed, suited for use by developers of search environments designed for children. In the collaborative interaction model also the interaction with the interface itself is an important issue for research and evaluation.

An important aspect for evaluating collaborative search is the analysis of interactions during a search task. This can help to identify target and non-target oriented actions and possible obstacles which distract children from being successful and keeping the flow in a collaborative search. Detailed action analysis can also help to evaluate in how far the collaboration has to be scripted and if children are capable collaborators or not. Finally, real-time action analysis can be used to implement intelligent interfaces that adapt or transform during a task depending on the concrete needs of a user.

Such action based logging possibilities are for example provided by the *Common Logfile Format* (CoLoForm) (Harrer, Martinez-Mones, & Dimitracopoulou, 2009). CoLoForm is an XML-based representation of user actions in interactive and collaborative applications. It has been conjointly designed by 9 European research groups within the Kaleidoscope Network of Excellence (NoE). It has been tested and used in Kaleidoscope for the implementation of a cross-system analysis of research data. It has also been used in the project Argunaut (ARGUNAUT, 2005-2008) with 2 argumentation systems supported by one joint moderation framework. There are already tools and components developed on the CoLoForm framework:

- Generator / Logger to create XML from object-based representations
- Parser to create objects from XML
- Analysis components
    - o Argunaut awareness interpreters and machine classifiers – visualisation and AI-based classification of collaboration
    - o PAnDiT pattern analysis and discovery tool – educational mining of research corpora (Harrer, Lingnau, & Bientzle, Interaction Analysis with dedicated logfile analysis tools: a comparative case using the PAnDit tool versus manual inspection, 2009)
    - o SAMSA social network analysis tool (Marcos, Martinez, Dimitriadis, & Anguita, 2006)

Since the mechanisms described above have already been used successfully in other contexts and projects, PuppyIR will not develop and implement new interaction data logging formats. If needed, we will make use of CoLoForm to provide developers, researchers, and users of the search interfaces and systems built with the PuppyIR open source framework to analyse and research collaborative search interactions of children using PuppyIR. We will also have an option to collaborate with one of the above mentioned research groups.

6   Conclusion

This report describes multiple opportunities to provide search environments which are suitable for children and which are appropriate to stimulate collaboration in various situations such as open learning spaces like museums, closed environments like classrooms and situations which are not necessarily targeting at learning. In our ongoing project activities we will implement and research different settings which will be evaluated and reported in D2.4, Evaluation of novel interfaces in demonstrator systems.

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Overview of Figures & Tables