Designing Storytelling Technologies to Encourage Collaboration Between Young Children

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ABSTRACT

We describe the iterative design of two collaborative storytelling technologies for young children, KidPad and the Klump. We focus on the idea of designing interfaces to subtly encourage collaboration so that children are invited to discover the added benefits of working together. This idea has been motivated by our experiences of using early versions of our technologies in schools in Sweden and the UK. We compare the approach of encouraging collaboration with other approaches to synchronizing shared interfaces. We describe how we have revised the technologies to encourage collaboration and to reflect design suggestions made by the children themselves.

Keywords

Children, Single Display Groupware (SDG), Computer Supported Cooperative Work (CSCW), Education, Computer Supported Collaborative Learning (CSCL).

INTRODUCTION

Collaboration is an important skill for young children to learn. Educational research has found that working in pairs or small groups can have beneficial effects on learning and development, particularly in early years and primary education [14, 19, 20]. Technology offers an opportunity to support and facilitate collaborative learning in many respects [1, 13]. The computer can provide a common frame of reference and can be used to support the development of ideas between children. However, neither learning nor collaboration will occur simply because two children share the same computer [13]. Numerous factors must be addressed, not least of which is the learner-machine interface. Today's technology is designed to support either one individual at one computer, or one individual collaborating with another individual at a different computer. However, much if not most, classroom computer use involves pairs or small groups sharing the same computer, especially in primary or elementary schools. What we have come to call *shoulder-to-shoulder collaboration*, as distinct from distributed collaboration, is not well supported with today's interfaces.

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In this paper, we explore the design of storytelling technologies to help develop collaboration skills in children aged 5-7 years. This is a particularly interesting group to work with because previous research has shown significant changes in the ability to collaborate effectively within this age range [21]. Young children find it difficult to collaborate effectively. Informal observation of behavior in our project has found that the youngest children (aged 4 and 5) have the most difficulty in working collaboratively and cannot work effectively at all in groups greater than 2.

We introduce an approach to the design of shared interfaces that involves subtly *encouraging* children to explore the possibilities of collaborating, without forcing them to do so. The aim is to provide opportunities for children to discover the positive benefits of working together, for example by being able to create new graphics and effects for their stories.

Encouraging collaboration is more proactive than only *enabling* collaboration. Something new is gained by choosing to work together, although the children may work independently if they wish. On the other hand, it is not as rigid as *enforcing* collaboration, for example by demanding that two children have to synchronize their actions in order to succeed, an approach that has been tried before with some positive gains in terms of individual development [5]. The approach of encouraging collaboration is intended to combine the educational goal of learning collaboration skills with our design philosophy of giving children control as much as possible. We also suspect that long-term educational gains might be made when children discover collaboration for themselves.

From an HCI point of view, the terms encouraging, enabling and enforcing collaboration can be related to previous approaches to the design of shared interfaces. Early approaches such as "What You See is What I See" (WYSIWIS) enforced strict synchronization of different users' views onto a shared workspace [16]. Subsequent approaches such as relaxed-WYSIWIS [15], coupled with techniques for promoting multi-user awareness [11] and concurrency control mechanisms for interleaving users' actions [10] have focussed on enabling the possibility of collaboration while retaining a high degree of individual autonomy. The approach of encouraging collaboration lies somewhere between these two and so offers a new variant on approaches to designing shared interfaces.

The research described here has been carried out within the KidStory project, a collaboration between researchers, classroom teachers, and children (5-7 years old) from England, Sweden, and the United States. The goal of the project is to develop collaborative storytelling technologies for young children. The KidStory technologies are based on the approach of Single Display Groupware (SDG), where several children interact with a single display using multiple input devices, for example, two independent mice [6,4,12,18,17]. In its first phase, KidStory has worked with two pre-existing technologies, a shared drawing tool called KidPad [8] and a shared 3D environment called the Klump (an application of the DIVE collaborative virtual environment system [9]), both initially with one mouse and later with multiple mice. KidStory has used the methods of cooperative inquiry [7], to involve children as technology design partners in an intergenerational and interdisciplinary design team. To accomplish this, a year-long series of technology design sessions were conducted in two schools in England and Sweden involving more than 100 children.

The following section describes the initial KidStory technologies. We then introduce the approach of designing interfaces to encourage collaboration and describe its use in the redesign of KidPad and the Klump.

THE INITIAL VERSIONS OF KIDPAD and THE KLUMP

We have been working with two collaborative storytelling technologies, KidPad and the Klump. Both enable two or more children to create and tell stories together, but differ in style, KidPad being derived from drawing and the Klump from sculpting or modeling. In the following we describe them as they were at the start of this research, before being extended to encourage collaboration.

KidPad

KidPad is a shared 2D drawing tool that incorporates a zooming interface. Children can bring their stories to life by zooming between drawing elements (see Figure 1). Zooming and spatial structure lie at the heart of KidPad, since they enable children to add narrative structure to their stories by dynamically moving between different parts of a drawing. The creation of a story in KidPad, which involves creating links and zooming between picture/scenes or zooming deeper into the scene, is intended to allow the development of non-linear, complex structured stories. These story representations might make salient the links between scenes and the overall structure of the story. We anticipate that the focus of the children's attention on these features of the story structure will provide new opportunities for learning, in a different and complementary way to the creation of a story using more traditional drawing or word-processing packages.

The KidPad interface is designed around a series of graphical "local tools" that children pick up and apply using

Figure 1: A sequence of views in KidPad as we zoom into a simple story (from left to right, and then top to bottom)

a mouse [3]. The tools are:

Crayons – different coloured crayons can be used to create drawing elements.

Arrow –a selection tool that can pick up and move objects.

Eraser – can be used to delete drawing elements.

Magic wand – can be used to create zooms between different drawing elements. The child selects the drawing element to be the start of the zoom followed by the destination element and sees an arrow linking the two.

Hand – can be used to activate zooms when the story is being told. Selecting the start point of the zoom initiates an animated zoom to the end point.

Turn alive – this tool animates a story element by causing its outline to ripple, making it appear to be alive.

Bulletin Board – this tool enables children to save stories to a bulletin board.

Toolbox – this special tool is used to organize the other tools, and can be opened or closed.

KidPad is a Single Display Groupware system, which means that it supports several mice plugged into a single computer. Two or more children can independently grab and use different tools at the same time using their own mice. Any free tool can be picked up and the children see each other's cursors. As a result, this initial version of KidPad could be said to *enable* collaboration – the children can choose to work together or individually. Figure 2 shows an example of the KidPad interface.

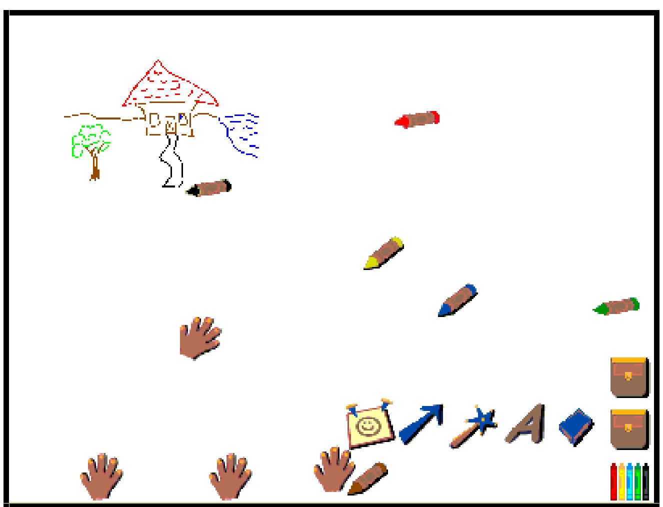

Figure 2: The initial version of KidPad showing all the toolboxes open at once with four simultaneous users.

KidPad is built on the Jazz[1] [2] and MID[2] open source Java toolkits. Jazz supports Zoomable User Interfaces by creating a hierarchical scenegraph for 2D graphics and MID supports multiple input devices for Java.

The Klump

In contrast to the drawing based approach of KidPad, our second storytelling tool, the Klump is based on a modeling approach. The Klump is a collaborative 3D storytelling tool based around an amorphous 3D object (in fact, a textured deformable 3D polygon mesh) that can be stretched, textured and coloured and that makes sounds as it changes and is manipulated. Figure 3 shows an image of the Klump after it has been stretched and textured.

Figure 3: The Klump, a deformable 3D modeling object

As with KidPad, two or more children can manipulate the Klump at the same time. The Klump is intended to be a more improvisational storytelling tool than a structured one. Our aim is for the Klump to provide a starting point for generating stories and characters in a way that a blank page sometimes may not. In other words, the real-time exploration of the properties of the Klump might lead to the creation of simple stories. We also intend that the flexible and amorphous nature of the Klump might inspire a wide range of different stories. Again, by supporting synchronous multi-user access and by displaying the children's cursors to one another, the Klump enables collaboration. The initial version of the Klump can be manipulated in the following ways:

Stretching – a point on the surface of the Klump can be grabbed using the mouse and can be pulled to deform its shape. There is an option to switch between pulling a single vertex and a group of vertices, thereby changing the kind of deformation that occurs. The single vertex option pulls out a thin volume of the Klump, whereas the group of vertices pulls out a thick volume. There is also a button to return the Klump back to its original spherical shape.

Texturing – a variety of pre-defined textures may be applied to the surface of the Klump by selecting buttons on the interface. These textures allow different facial expressions to be added to the front side of the Klump,

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[1] Jazz is available at *http://www.cs.umd.edu/hcil/jazz*

[2] MID is available at http://www.cs.umd.edu/hcil/mid

giving it a sense of character, and enable its background colors to be changed.

Rotating – the texture on the surface of the Klump can be grasped and rotated around to a new position.

Finally, the Klump makes a variety of sounds to reflect these different manipulations.

INTERFACES TO ENCOURAGE COLLABORATION

The core technical innovation of this paper is the idea of designing interfaces to encourage or invite children to collaborate. This has been motivated by our experiences of using the initial versions of KidPad and the Klump in two schools, one in Sweden and one in England, during the 1998-1999 school year as part of a program of activities that included:

- **contextual inquiry** – sessions to observe how children work with existing storytelling technologies (e.g., crayons and paper) and how they collaborate.
- **participatory design** – initial sessions to establish the children in the role of design partners and co-inventors of technology, followed by sessions with KidPad and the Klump aimed at eliciting specific design suggestions. These are reflected in the redesign of these technologies described later on.
- **evaluation of the technologies** – observations of how the children used the initial versions of KidPad and the Klump.

Over the course of the year, the combination of these activities has resulted in more than fifty sessions in schools involving more than one hundred five and seven year olds. At the peak of this activity, there were weekly participatory design and contextual inquiry sessions.

Children were observed with respect to collaborative behavior and their ability to use the technology to tell stories. Children and teachers were encouraged to provide feedback on these technologies that would instigate changes in design. Although after a few months, small-group and whole-class collaborative storytelling activities were being performed using these technologies, it was evident that some children found collaborating difficult.

Interfaces that encourage collaboration were proposed as a way of addressing this problem. Such interfaces should provide opportunities for children to discover the positive benefits of working together. Ideally, this should be achieved in as subtle and natural a way as possible, avoiding forced solutions. As noted in the introduction, encouraging collaboration is more proactive than only *enabling* it as was the case with the initial versions of KidPad and the Klump described previously. On the other hand it is not as extreme as strictly requiring collaboration, for example, demanding that two children have to press a button together to achieve an action, the approach that we described as “enforcing collaboration”.

In its strictest interpretation, the approach of encouraging collaboration without enforcing it would require that a single child could achieve on their own any action that two children could achieve together, but that the two would do so in an easier, more efficient or more fun way. However, a more relaxed interpretation, is that a single child can carry out all of the major classes of action supported by the tool, but that by working together, two children can achieve subtle extensions to and variations on these actions. For example, a single child or two children working independently can create a functioning drawing in KidPad, but two children collaborating can create an enhanced one. This more relaxed approach is the one that we have adopted in revising KidPad and the Klump. However, before describing their redesign, we briefly digress to consider the more general relationship between the approach of encouraging collaboration and previous work on the design of shared interfaces in some more detail.

Relationship to previous work on shared interfaces

Up to now, we have introduced the idea of interfaces that encourage collaboration within the context of educational applications. We now consider its broader relationship to CSCW technologies, especially how it compares to other approaches to synchronizing shared interfaces

How to synchronize shared interfaces has been a major concern for CSCW research. This has predominantly focused on distributed groupware where multiple users share a common workspace, for example a shared document, 2-D sketch tool or 3-D virtual world, using separate displays connected over a computer network. In such cases, the problem of synchronization can be broadly broken down into two parts.

How to synchronize what different users see? One of the first approaches was WYSIWIS (What You See Is What I See) where different users at different displays were forced to see the same part of a virtual workspace [16]. Experience with WYSIWIS led to less strictly coupled approach called relaxed WYSIWIS where different user’s views could diverge [15]. Systems adopting this approach typically introduce additional functionality to support users in being aware of where others are looking and what they are doing. This may take the form of various awareness widgets, such as ‘radar views’ in 2D workspaces [11] or visible user embodiments (‘avatars’) in 3D systems [9].

How to synchronize object manipulations? Many CSCW systems allow users to collaboratively manipulate objects, changing their state. Examples include jointly editing a shared document or grasping and moving objects in a virtual world. This raises the problem of how to prevent conflicting updates. The most common solution is some form of locking, including simple turn-taking protocols, optimistic locking, non-optimistic locking and serialization protocols that allow participants to interleave their actions at various granularities [10]. Another option is social locking where given sufficient mutual awareness, user’s may be able to negotiate mutual access with minimal system intervention.

We suggest that these various strategies can be located along a “collaboration continuum” according to the extent to which they constrain individual autonomy and demand collaboration or leave users free to act independently. One extreme of the continuum involves what we have called *enforcing collaboration*, where the users are locked in step with one another. WYSIWIS and strict turn-taking can be found here. So can the work of Light, Foot and Colbourn, who modified the input of a standard computer so that two students had to enter information at the same time to succeed [5]. A kind of dual key control was used. It was found that this enforcement of collaboration improved individual cognitive development. At the other extreme is what we have called *enabling collaboration*, where the users can act independently, are mutually aware and are free to coordinate their actions if they wish. Relaxed-WYSIWIS and social locking can be found here.

Our approach of *encouraging collaboration* lies somewhere between the two. It is not so strict as to require users to work together, but it provides some explicit motivation for them to do so in terms of added benefit. As noted earlier, encouraging collaboration can be interpreted in different ways. The case where a single user could achieve any action, but multiple users can achieve it in a way that is easier or more fun lies towards the enabling end of the continuum. The case where a single user can carry out each general class of action, but where multiple users can achieve enhanced actions lies towards the enforcing end.

It should be noted that a single CSCW system can use different approaches for different actions. For example, collaborative virtual environments often enable collaboration for viewpoint control (each user steers their own viewpoint, but is made aware of others’ viewpoints through their embodiments), but enforce it for object manipulation (there is a turn-taking or coarse locking protocol regarding who can grab a virtual object).

This discussion raises the question of how the approach of encouraging collaboration might be applied in areas other than educational applications. One possible application area is in entertainment and games applications where participants might choose to collaborate, pooling abilities and resources to mutual benefit. Another more subtle approach might be in situations where participants can benefit by sharing costs. People increasingly have to pay for the use of network resources, for example in video and audio streaming. Users who agree to collaborate, for example to receive or manipulate the same information might be rewarded by sharing the costs between them.

REDESIGNING KIDPAD AND THE KLUMP TO ENCOURAGE COLLABORATION

We now describe how KidPad and the Klump were redesigned according to the lessons learned from the various schools sessions. Our overall strategy was to introduce design changes that satisfied two criteria:

- first they should encourage collaborative activity, reflecting the project’s educational agenda and reacting to the observations noted previously.
- second, they should be based on the children’s own design suggestions, emerging from the cooperative inquiry process.

Our general approach has been to use the more frequently occurring of the children’s ideas as the basis for deciding on new functionality, but to realize this functionality through the approach of “encouraging collaboration“.

Redesign of KidPad

The basic approach that we followed in redesigning KidPad to encourage collaboration was to support tool “mixing“. By this, we mean that when two (or sometimes more) children each use mixable tools at about the same time and place, the tools give enhanced functionality.

As a concrete example of this approach, consider the operation of the crayons in KidPad. The initial version provided three colors. A frequent design suggestion from the children was to provide more colors. We immediately added three more crayons, but that wasn’t enough. Our final solution is to enable children to collaborate and combine their crayons to produce new colors. If two children draw with two crayons close together, then the result is a filled area between the two crayons whose color is the mix of the two. In this case, the children are not prevented from drawing as individuals, but they can gain additional benefit (new colors and filled areas) by working together.

Applying our approach involves examining combinations of actions to look for interesting benefits and effects. We can consider all actions combined with themselves, for example, what happens when two selection tools are used together in KidPad? We can also consider how actions combine with other actions, for example, what might happen if one child rotates the Klump while another stretches it? In each case, we look for effects that are natural and useful rather than contrived.

As described above, crayons in KidPad now work this way by drawing a filled in area between the two crayons using a color that mixes the two crayon’s colors. By introducing collaborative color mixing, we added 15 mixed colors with the six crayons, and filled areas while encouraging collaboration and without adding any new tools (see Figure 4). Also, we added a special “duplicating“ tool that makes copies of other tools so several children could use the same tool type simultaneously. Figure 4 shows the redesigned interface with two children using mixed crayons.

Figure 4: Redesigned KidPad interface with mixed crayons being used. Note that inactive tools are faded. There are three active crayons, and two are currently being used to create a "mixed" area.

We built in mixing capability for multiple uses of all tools, except the magic wand and toolboxes. In every case, we tried to add a special behavior that acts as if it is a natural extension from the behavior with a single user. We felt this design ideal to be important in order to make it as easy as possible for children to anticipate what the mixed behavior might be. The mixing behavior we added is:

Crayons – As described above.

Arrow – Two or more children can squash and stretch selected drawing objects.

Eraser – One user can erase bits of a drawing object, but two children can erase an entire drawing object at once.

Hand – Two or more children can zoom in and out by moving their hands apart, or closer together, respectively.

Turn Alive – Two or more children can control the animation properties of a wiggling object by moving the turn alive tools closer together or further apart.

Redesign of the Klump

In redesigning the Klump to encourage collaboration, we have focused on combining the actions of stretching and texturing with themselves.

Stretching – the initial version of the Klump enabled toggling between two modes of stretching, pulling out a single vertex and pulling out a group of vertices. The revised version enables a single child to pull out only a single vertex on their own. However, if two children synchronously pull out two vertices that are close together on the Klump's surface, the result is to pull out a whole group of vertices. Thus, the added benefit of collaborating is to be able to make a different shaped deformation.

Texturing – our redesigned version of the Klump enables the children to apply a limited number of textures to its surface by pressing buttons. The textures represent happy and sad faces as well as background textures for the three primary colors. These may be applied independently so as to combine each of the two faces with the three background colors. However, by pressing some buttons together, the children may arrive at new combined textures. Three new faces become possible: laughing (pressing happy and happy), a kind of surprised expression (pressing happy and sad) and crying (pressing sad and sad). In addition, the background colors can be selected together to make new combined colors (similar to combining the crayons in the revised KidPad). A single user can also select the combined textures by selecting one button and then another a short time after (while the first is seen to rotate), but it requires speed and skill.

We have also extended the sounds made by the Klump to provide feedback as to when collaborative effects are being triggered, for example, by saying "cool" and "yippee".

Figure 5 shows the revised Klump interface. In the center we see the Klump, currently with its laughing face on a red background. To its left are the two buttons that are used to apply happy and sad face textures. To its rights are the three buttons for applying the colors. Above the Klump are two buttons that toggle between using a mouse for stretching and using it for rotating. The red button at the bottom returns the Klump to its original shape.

Figure 6 shows the difference between single-user and collaborative stretching. On the left we see the results of a single user stretching the Klump, pulling out a single vertex. On the right we see a collaborative stretch that pulls out a group of vertices, making a larger deformation.

Figure 7 shows the different facial expressions that can be obtained using the two buttons at the left of the interface. Faces 1 (happy) and 2 (sad) are obtained by a single user pressing the button. Faces 3 (laughing), 4 (surprised) and 5 (crying) are obtained when two users select combinations of the buttons at once (happy and happy gives laughing, happy and sad gives surprised, sad and sad gives crying).

Initial reflections on the revised interfaces

Although no formal program of evaluation has yet been carried out, the revised versions of KidPad and the Klump have been tested with a few groups of children.

The revised version of KidPad was introduced to our school in Nottingham. Pairs of children were given the common goal of recreating a well-known nursery rhyme. The children appeared to collaborate effectively, working on separate parts of the story and then joining together to use the collaborative tools to color in their picture.

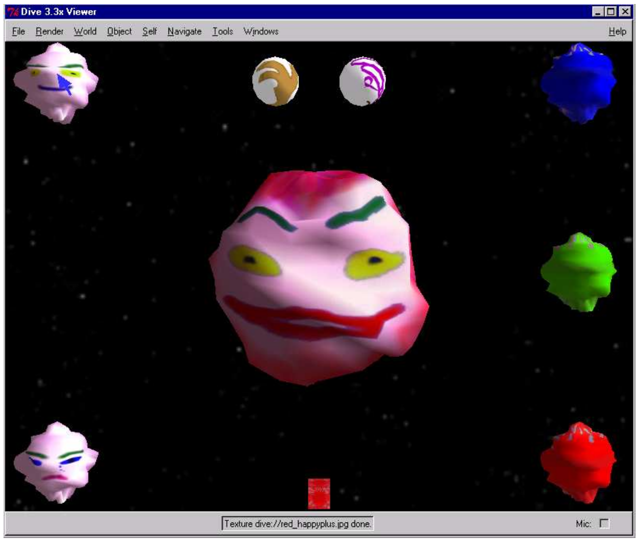

Figure 5: the revised Klump interface

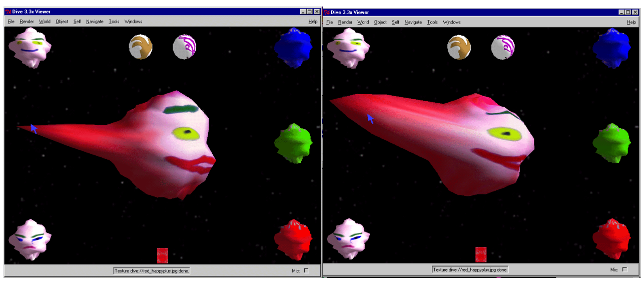

Figure 6: single user and collaborative stretching

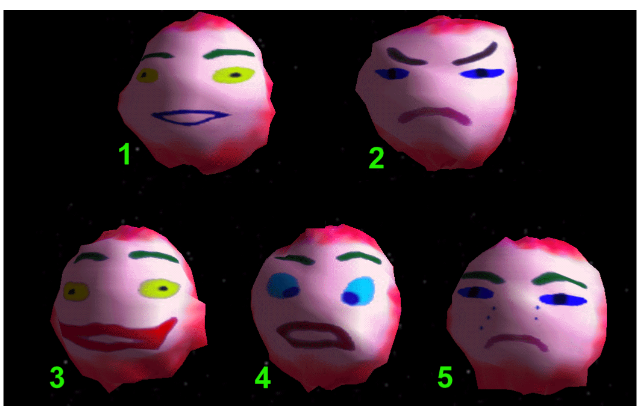

Figure 7 : facial expressions for the Klump

Two children from the UK tested the re-designed version of the Klump. While the children explored features of the Klump, including the collaborative features, they did not show much interest in working together. This may in part, have been the result of them having no explicit 'shared goal'. This session, however, did raise an issue that should be considered when developing tools to encourage children's collaboration. When two young children carry out a collaborative action, the resulting effect has to be really obvious and noticeably different from the effect displayed when the children carry out the action independently.

The revised versions of both KidPad and the Klump were also informally tested with a small group of children that are design partners at the University of Maryland's Human-Computer Interaction Lab. This formative evaluation showed that it took considerable experience with KidPad and the Klump for children to make use of the collaborative tools. For example, in a one-hour session where two boys (ages 10 and 8) used the Klump, it took almost 25 minutes for the children to discover the collaborative features. (These children on a previous occasion had used a less collaborative version of the Klump for a twenty minute session). They were then shown the collaborative features by an adult. In their comments afterwards said that they had enjoyed changing the faces and mixing colors.

Another formative study was carried out with six children (4 boys/2 girls; ages 7-10) using KidPad. For an hour and a half session, the three children who had previously worked with KidPad (a single-mouse version) showed strong differences in their use of collaborative tools, than the three other children who had never seen KidPad before. The children formed two teams, and each team worked on a computer with three mice. The children that already had used KidPad formed one group, and the children that hadn't used KidPad formed another group. After introducing KidPad and the new collaborative tools to the group, the children freely explored the tools for 20 minutes. Then, the children were asked to create a story with at least three "scenes" to zoom to and from. The experienced children had little trouble creating a story. They collaborated throughout the process, making extensive use of the collaborative tools before starting the story, trying out the different possibilities. However, interestingly enough, they did not use the collaborative tool behaviors in the actual story creation.

The children that used KidPad for the first time had a harder time collaborating to create a story. They tended to experiment with the tools, including the collaborative tool behaviors. Most of what they did however was scribbling. This group found it hard to identify each other's cursors and to negotiate collaboration.

These early observations suggest that young children are able to use some of the collaborative features of KidPad and the Klump and that they can enjoy doing so. On the other hand, the way these features work has to be made more obvious in some cases. Furthermore, discovering them in the first place is a problem and they had to be pointed out by an adult on several occasions. On reflection, we realize that our designs only showed the results of collaborating, but did not highlight in advance when the possibility existed. We have therefore begun to revise KidPad and the Klump to more explicitly show the potential to collaborate. An example of this can be seen in Figure 4 that is actually taken from the most recent version of KidPad. The two dots above the crayons are eyes that only appear when the crayons are close enough for the color mixing and filling to happen. We hope that steps such as these will help the children discover collaborative possibilities for themselves.

SUMMARY AND FUTURE WORK

In summary, we have proposed a new approach to designing shared interfaces that is intended to support children in learning to collaborate. The approach, called encouraging collaboration, allows children to work as individuals, but gives added benefits if they choose to work together. We have demonstrated this approach applied to the design of two storytelling technologies within the more general framework of cooperative inquiry within UK and Swedish schools. We have compared our approach with other user interface mechanisms from CSCW.

Future work will involve further design changes to KidPad and the Klump to reflect our early experiences. We will then undertake a more rigorous programme of evaluation including the development of a more intricate coding system, focusing on verbal and non-verbal collaborative behaviors, tracked from video recordings of the children and computer tracking of the children's interactions.

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