

# An Annotation Support System for Middle School Teachers and Students in the ICDL

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## ABSTRACT

In this paper we describe a system for middle school students and teachers that combines the affordances of paper with the affordances of digital books. Our teacher composer tool focuses on providing teachers with tools to annotate books with reading comprehension hints for their students. The student annotation tool focuses on providing students with highlighters, stamps and sticky notes to aid them in better understanding their reading. The Interactive Workbook provides not only the functionality of a free-form note-pad, but begins to incorporate structured reading activities that teachers create to help students further explore concepts in books. Our preliminary user study shows that (*something like: this tool helps students better understand books they read and helps teachers compose more comprehensive lesson plans*). The tools we have designed successfully make use of paper affordances in the digital domain, giving teacher and students a powerful alternative to paper-based worksheets and books.

## Keywords

Educational technology, digital libraries, annotation, children, paper and computers, cooperative inquiry

## INTRODUCTION

Paper offers many affordances over electronic documents, especially for interweaving reading and writing. Paper has four primary affordances for a user's interactions between reading and writing: tangibility, spatial flexibility, tailorability, and manipulability [17]. Digital documents have their own benefits, such as being easy to copy, store, retrieve, search and distribute. By combining the affordances of paper with the affordances of electronic media, users can benefit by receiving the best of both worlds.

In this paper, we describe our preliminary system that addresses some of these affordances of paper in a digital book reading system. Our system, an annotation support system for middle school teachers and students, is the result of our research into people, paper and computers, and our design work with an intergenerational design team.

The International Children's Library (ICDL) is a digital library for children ages 3-13. Preliminary design work for

the library has focused on children ages 6-11. In this paper, we extend upon the ICDL work to support older children and their expectations from a digital library, namely more support for their school-related activities.

There were three main goals when developing this annotation support system. This first goal was to use knowledge of people, paper and computer interaction and attempt to design our system to encapsulate the affordances of both paper and digital media for annotation. The second goal was to include both children and teachers as design partners to create an annotation system (which was integrated with the ICDL) to address the needs of teaching children about annotating while reading – as well as allowing teachers and students flexibility to write and annotate inside books which is not possible under normal circumstances. The third and final goal was to build an initial prototype of such a system to better understand how the design ideas from the children, teachers and current HCI literature will interact.

In our attempt to achieve these goals, we designed an annotation book-reader that has two parts. The first is the student-centered annotation system that our child design partners helped to create. This interface supports highlighting, adding stamps to a book to indicate various levels of understanding, and a sticky-note function that allows the students to add notes to the stamps, to further clarify questions or comments about a highlighted section or to add general comments about a page of a book. The second part is the teacher-focused composing tool. This interface supports teachers' annotations of a book, which can help their students better understand the text that they are reading. Teacher annotations are focused around adding stamps to the margins, giving the students feedback about a particular section of a book. In addition, teachers may want to underline vocabulary (or unknown words) within the text to indicate to students that they should look up those words. Another major component of our system is the Interactive Workbook, which can be made visible alongside the book that is being read. Teachers can develop assignments using our Workbook Creator, with the option to use templates intended to help students learn while reading. Students can use the Interactive Workbook

to complete these assignments, as well as using a blank notepad contained within the Workbook to compose ongoing notes about the book (i.e. for a book report or essay).

We believe that classrooms provided with our annotation system will learn better reading comprehension skills. This is due, in part, to the fact that our system allows direct manipulation of books and allows teachers to incorporate annotations within a text, neither of which is currently easy to do in our classrooms. By working with both students and teachers while designing this system, we were able to implement features that reflect the needs of middle-school classrooms and their unique learning goals. (*Future*) user studies (*will hopefully*) show the level to which our system can aid students with their reading comprehension skills.

### RESEARCH METHODS

Using the cooperative inquiry research methods pioneered at the University of Maryland [5, 6] and extended to older children [10], we have explored our ideas for an annotation system that combines the benefits of paper and of a digital system with our new intergeneration design team, consisting of 6 children ages 10-13 and 6 adults.

During cooperative inquiry activities, we explored how the current ICDL system failed to meet our design partner's expectations. One major area where expectations were not met was in supporting the children's schoolwork activities. Students of this age are beginning to read to learn [4] and so they expect that a digital library should provide resources to support reading for learning. While building this system, we worked closely with our child design partners to strengthen the annotation support system.

We also collaborated with a middle-school teacher to discuss our interface ideas. This collaboration reinforced many of the ideas we had, but also led us to consider a more teacher-related focus in addition to the interface ideas we had considered with our design partner children. (*Will be working with more teachers in an ethnographic sort of way, and will talk about that here as well.*)

### PREVIOUS WORK

There has been a large amount of previous research into annotation systems, but these have been primarily focused on how adults read – in college or in the work place. There have been numerous studies about adults and reading, as well as systems that address the reading and annotation needs of adults. There are few studies about how children read. Education research has focused on how to teach children reading and strategies to aid comprehension, but there is not literature on how children use this school knowledge while reading and annotating books. Also, literature has shown that children are a special user group, and their skills and abilities need to be considered when designing interfaces. Finally, design partnering with children has proven effective for designing interfaces for children. We will discuss each of these factors in turn.

### Adults - Reading/Annotation Studies and Technology

Digital library reading appliances have been studied to understand how people make annotations on a reading device and how the device affected annotations [12]. Sellen and Harper [17] discuss four affordances of paper for interweaving reading and writing: tangibility (easy to flip through paper), spatial flexibility (can cross-reference easy and spread papers out), tailorability (can mark on paper with a variety of annotations), and manipulability (easy to push paper aside and move things back and forth while working). While designing our prototype, we have considered what aspects of these affordances would be most useful for child readers.

Similarly, another study compares reading from paper to reading on-line [14]. This study presents a substantial amount of literature in this area. In addition, it discusses how annotation can help readers deepen their understanding of texts. This is especially important for students reading for school assignments, as the goal is to help the students understand what they read better. In "How to Read a Book", Adler [1] discusses active reading and how it entails three ways of reading a book: structural (proceed from the whole to its parts), interpretative (proceed from parts to the whole), and critical (judge author by agreeing or disagreeing).

Many systems have been built for supporting adult's online reading and annotation, focusing on system design and the difficulties of providing robust annotations [3, 7, 11, 16]. However, even the most sophisticated paper-like device built to-date, XLibris [16], is a highly specialized, expensive device designed for lawyers and thus would be an inappropriate requirement to provide full support to children from all cultures and economic backgrounds.

### Children - Reading Studies and Motor Abilities

There are not many studies about how children read, but there is extensive research that discusses how to teach children about reading. For example, Robb discusses the following strategies for teaching reading in middle school: activate prior knowledge, decide what's important, synthesize information, draw inferences during and after reading, self-monitor comprehension, repair faulty questions, and ask questions [15]. These books and our conversation with the middle school teacher(s) helps our system leverage off of the known strategies of teaching children reading.

Child development research tells us that children in grades 4-8 are in a stage where they are reading to learn (in contrast to grades 2-3 where they are reading to increase fluency) [4]. In this stage, children relate print to ideas, generally from one viewpoint. Hence, annotation becomes important as children struggle with reading comprehension and essay writing tasks. These strategies are less sophisticated than adults', but special forms of annotation can support their activities.

Since we will be relying on the mouse as the input device for most activities, designing an interface for children in which they have to execute pointing tasks will require certain guidelines. Hourcade recently provided such guidelines in his empirical study on the performance of children with mice [8]. Although most of his strategies are geared toward preschoolers, he provides ample evidence that interface designs should accommodate younger users.

### A KID'S PERSPECTIVE

While doing the preliminary design work for our annotation interface, we interviewed an advanced child user, who had been a member of the UMD KidsTeam for 5 years and was very knowledgeable about interface design. We also worked with our intergenerational design team, using cooperative inquiry research methods.

During our interview with the 13-year-old advanced user, he told us that interaction with a teacher while reading for school assignments would be a great feature to add to the library. He envisioned a system in which students could send messages to the teachers while reading or to send teachers a page from a book with sticky notes attached. He suggested that reading comprehension questions be attached to the book so that answers could be typed directly in and then sent to the teachers. He discussed the functionality that he would want from bookmarks: that the system should automatically bookmark the last page that a student left off at and that other page-markers should be easy to find and include the ability to add a name to the particular bookmark. He also told us that it was important to have everything immediately on the screen, so the interface was not too complicated. In addition, he felt it was important not to add too many bells and whistles, because then students might spend too much time playing with the interface and not focusing on the text or assignment.

### Designing the Annotation Bookreader

We have also structured many cooperative inquiry design activities with our intergenerational design team in order to improve our design by exploring ideas with our child partners. During these activities, we learned about the type of reading-related homework that our child design partners have experienced. We learned that different teachers require many different strategies for reading comprehension and tracking the reading that their students do. We then designed what tools would need to be added to the ICDL to support these homework activities.

Two of the designs that our team came up with are pictured here (Figure 1 and Figure 2). One design was a tabbed window in addition to the book page that you were reading, to answer reading comprehension questions, to do reading logs, or story-mapping.

Another focused on highlighting, stamping and on supporting books in foreign languages and doing translations. The third focused on how to customize an interface, having a personal bookshelf where your friends

and teachers could add books, and bookmarks and post-it notes that could be added to personal copies of a book.



**Figure 1: A sample annotation system**

Additional features that were discussed were dictionary and thesaurus functions, searching for words within the text, buttons for various types of reading logs, dragging text from book or sticky notes to a separate note page (for writing an essay or book report), spelling and grammar check for the note page, and an eraser for getting rid of old or unwanted annotations.



**Figure 2: A sample annotation system**

From these activities with the intergenerational team, we noticed that many of the design ideas supported our notions of capturing the flexibility that paper affords in a digital interface. The ideas generated also reinforced our ideas of how we thought students might want to annotate, and demonstrated how important it was to consider school related activities. This is because most book annotations at this age are done solely for coursework.

### A TEACHER'S PERSPECTIVE

To understand better how teachers think about their student's annotation habits and how the students learn how to annotate, we talked with a sixth-grade reading teacher. (Note: we will have to talk to a few more teachers this summer in order to get a more balanced perspective).

Throughout her XX years teaching in the classroom, she has tried a variety of methods to engage her students in reading. She claims she has had the most success with a

derivation of the *Clicks and Clunks* technique [9], which she first learned at a countywide teacher's conference. In the technique's original form, a student is supposed to decide after each sentence if it made sense. If it was comprehensible, they should shout out *Click*. If they did not understand, they should shout out *Clunk*, making the teacher aware that there is something in the sentence that is troubling them. Once the children become comfortable with this strategy, the teacher can give the children less audible signals to respond with.

At a sixth grade level, most children were fluent enough with reading that *Clicking* every sentence would become cumbersome. The reading teacher with whom we consulted also wanted a way to receive these signals even when the students were reading on their own at home. Therefore, she took a slightly different approach to *Clicks and Clunks*. First, she altered the meaning of *Click* from a heuristic of simple comprehension to one of importance. Now whenever students came across a sentence they felt was important or integral to the story, they would *Click*. *Clunks* retained their original meaning. Her second change facilitated her lack of presence in reading-at-home situations. She gave the students a stack of Post-It notes, and required them to post *Click* sticky notes next to at least three sentences during each reading assignment. Similarly, there was a requirement of at least three *Clunks*. Not only would this give the teacher a gauge of what was troubling the students, but it would also provoke class discussion the next day when she could simply go around the room and ask the students what they *Clicked* the previous night.

The reading teacher was also quick to point out that most of her students do not know what to take notes on while they're reading, unless a clear focal point is given. She tends to alleviate this note-taking confusion by giving the students focus questions to think about before they start reading. She also makes use of prediction sheets, in which she asks the students what they feel will happen in the upcoming pages. These sheets are typically composed of such questions as "Which characters will be involved?" or "Which setting will the next part take place in?" She has had much success with engaging the students with these pre-reading exercises. She also has analogous procedures for post-reading activities, such as the use of journal entries.

The reading teacher also mentioned that the type of book has a direct impact on how fast the student will be able to process it. Typically, students read nonfiction at a much slower pace. To let the children know that it's okay if they are taking longer to read than normal, she will typically draw speed limit signs to make them aware of difficult passages. For instance, with a nonfiction text, she'll mark it with a "10 mph zone" symbol – so that they know to proceed with caution. Similarly, whenever there is certain vocabulary that should be paid attention, she'll underline or boldface the words. This also gives the students feedback

that it's okay if they're not sure what the word means – but that they shouldn't be hesitant to look it up.

The teacher also gave other, less-detailed suggestions of support that could help students. *During our summer work we will explore these ideas with other teachers.*

### **Designing the Teacher's Tool**

The design team had a significant role in creating the concept for the teacher's annotation system. During design sessions, child members shared how their teachers would monitor their reading and what types of activities that had to do along with reading assignments. This informed us of the child's perspective of what strategies work best to encourage reading outside of school. This helped us focus with the teacher we worked with on more specific questions about strategies used to teach reading.

Through the discussions with the reading teacher, it became clear that books were not expressive enough on their own to promote annotation for children. In order to elicit better note taking from students, teachers would have to provide focus and guidance. It was clear that in order for this to be possible, we would have to build a separate authoring tool for teachers to enhance the digital library books with distinct teacher annotations.

The teacher's suggestions have helped us focus the teacher-composing tool to allow teachers to annotate books based on strategies that they use in the classroom. (*Again we will need more teachers to really say that our system supports these multiple strategies.*) The teacher's design ideas helped reinforce some of the ideas that we heard from our child design partners, and to better understand the strategies behind the assignments teachers give their students.

### **A TYPICAL SCENARIO**

Imagine a situation in which a teacher assigns students to read a chapter of a book from the ICDL. The students are able to use the computers in the school computer labs, the library or even at home – since no special hardware or proprietary software is required. The teacher has assigned a book that is technically above their current reading level. Doing so in the past would have been impossible, as most of the students would have become confused and unable to continue. But the teacher is confident that the students will be able to complete the reading due to well-placed teacher stamps that warn the students of difficult parts and sticky notes that provide explanations of confusing sections. The teacher is able to ascertain if the annotations and assignment were successful or not by seeing where the students place *Clicks* and *Clunks*. Once the students complete their assignment, they can send it back to the teacher. The next day in class, the teacher is able to jump immediately into an explanation of the most challenging parts of the text by simply analyzing the portions of the book that have the highest frequency of *Clunks*. The teacher can gain more valuable feedback than was ever obtained in the past, as students that may feel shy or

inhibited to talk about their confusion in front of their peers during class may not feel that inhibition while working at their computers. Furthermore, the teacher has the ability to prepare in advance for specific questions that the students had annotated the previous night. The teacher is also able to determine which portions of the book sparked the most interest from the students, and therefore create an in-class project that will be sure to captivate the attention of the class. (Later will include something about the Workbook.)

### THE ANNOTATION SYSTEM

When designing our annotation system, we had several underlying goals in mind. We first wanted to allow students and teachers the flexibility to annotate books that normally isn't possible in classroom settings. For instance, most schools cannot provide their students with personal copies of the books used in class and are therefore forced to prohibit students from writing in the books.

We believe that by creating an intuitive annotation system, children will implicitly learn the value of active reading [1]. A second goal was to make our annotation as friendly as taking notes on paper – but also providing the digital benefits that go above and beyond what paper can provide.

Although both the students and the teacher will be annotating the same books in the library, it became clear that they each need more specialized annotation systems reflecting their personal uses of the system. The teacher's system focuses on providing guidance to the students reading the book, such as giving hints about difficult parts of the text, appending direct reading comprehension questions, and underlining words or sections the students should pay special attention to. The student's system focuses on understanding the text by taking notes and responding to reading comprehension questions.

We have built the annotation systems as part of the ICDL. The ICDL was originally built in Java using Jazz, a Zoomable User Interface (ZUI) toolkit [2]. In order to make use of the latest technology, Piccolo, which is a more efficient ZUI than Jazz [2], the bookreaders of the ICDL code were ported to support this new toolkit. The annotation tools we designed and implemented were built on top of this Piccolo version of the ICDL bookreader code.

### SUPPORTING STUDENT'S ANNOTATIONS

Aside from simply providing the ability to take notes and respond to reading comprehension questions, we knew it was important that the additional tools did not interrupt the student's reading flow. With this in mind, we designed and implemented the following tools based upon our work with the intergeneration design team.

#### Symbolical Highlighting

Highlighting was a feature that was important to child and adult design partners. Based on ideas from our child design partners about the type of sections they want to highlight and by using the concept adapted from the *Click and Clunk*

technique, we give the student users three different highlighters. When students do not understand a section of text, they can highlight it using the question mark highlighter. This highlights the text in red, a color that our design partners felt signaled an alert. In our design sessions we explored whether color alone was enough of an indicator, and discovered that it wasn't. So in the right margin next to the highlighted text, a question mark stamp is placed, to reinforce the existence of a "clunk" (Figure 3). Similarly, we designed the exclamation highlighter to show importance within the text. This highlighter was chosen to be yellow, the "typical" highlight color which usually indicates significance, according to our child partners. A corresponding exclamation stamp is also placed in the margins to show the student's "click". The third highlighter is the sticky note highlighter. This blue highlighter and sticky note stamp could be used for neutral reactions to the text. In addition, this sticky note stamp could be placed anywhere on the page to indicate a general comment about the page, without necessarily attaching it to a particular passage of text.

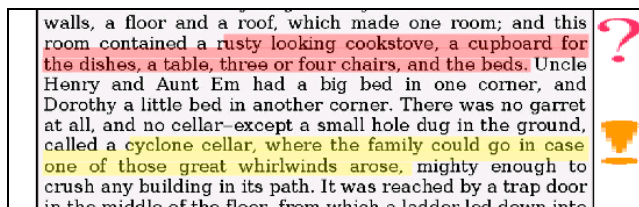


Figure 3: Question and Exclamation Highlighters

Originally, several members of the design team wished to allow a palette of highlighter colors for children to select from. But because of the school focus of the design, and in order to keep the annotation system being misused as a coloring book, we chose to only implement these three representative highlighter colors. If future input from teachers indicates a need for additional symbolical highlighters, more colors could easily be added.

#### Enhancing Symbols with Text

There are situations where highlighting and stamps don't provide enough information. For instance, if there were a particular question a student has about what was just highlighted, it would make sense to give the student an opportunity to record the question. To facilitate this need, we created zoomable sticky notes. If a student would like to record text about a particular annotation, he/she simply clicks on the corresponding margin stamp and the zoomable sticky note will appear (Figure 4). The student can then input any question or comment on the note. When the child is done creating the sticky note, clicking on the margin stamp will shrink the sticky note to a fraction of its size and attach it behind the margin stamp. The sticky note will no longer obstruct other text or annotations – but the zoomed-out representation will still give a visual clue that there is a sticky note attached with that margin stamp.

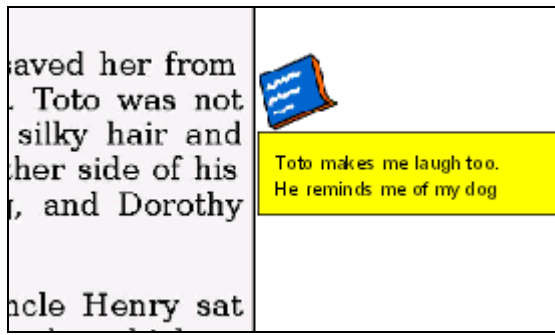


Figure 4: Margin Stamp with Sticky Note

### Intelligent Bookmarks

Another tool students can use is intelligent bookmarks. In this digital library setting, bookmarks are not just used to mark the page where the student was last reading. Instead, they can be used to easily draw attention to any page within the book. The bookmarks are described as intelligent because once a student marks a page, the bookmark will be automatically created with useful information, such as the page number and an analysis of what type of margin stamps the student has placed on that page. The bookmarks are also able to capture the affordances of tangible bookmarks because they are visually accessible by simply glancing at the top of the book, as shown in Figure 5.

p. 2	p. 2	p. 2	p. 2	p. 2	p. 2	p. 2	p. 2	p. 2	p. 2	p. 2	p. 2
02's	02's	02's	02's	02's	02's	02's	02's	02's	02's	02's	02's
1's	01's	01's	01's	01's	01's	01's	01's	01's	01's	01's	01's

until they were the same gray color to be seen everywhere. Once the house had been painted, but the sun blistered the paint and the rains washed it away, and now the house was as dull and gray as everything else.

When Aunt Em came there to live she was a young, pretty wife. The sun and wind had changed her, too. They had

Figure 5: Bookmarks (will re-do figure later)

The preliminary bookmark feature that we have built automatically includes the page number of the bookmark and the number of questions or exclamations the student has annotated on the page. Size, shape, or color could also be used to give a more powerful visual representation of distance, importance, or problems within the book. Design sessions have also indicated that it might be useful to allow the students to name their bookmark. These ideas will be tested will be implemented and tested during the summer (all or some of them).

### SUPPORTING TEACHER'S ANNOTATIONS

During our initial design of the annotation system, we assumed that students could take freeform notes based on worksheets or written homework assignments their teachers gave, such as reading comprehension questions or book reports. When it became clear that our system would be more powerful if we created a separate system for teachers, we implemented the following initial set of tools for teacher users.

### Pictorial Clues

Just like the automatically placed margin stamps that appear next to student's highlighting, teachers have the ability to stamp the text as well. Again, stamps are essentially small pictorial icons that appear in the margin of the text that they are pointing to – and they each carry a special meaning. We identified several initial stamps (Figure 6) that would be useful for teachers annotating a text to help their students. The checkmark stamp can be used for the teacher to point out a particular fact or interesting section of the book. As a result of our feedback from the sixth-grade reading teacher, there is also a speed limit stamp. This stamp was designed to inform students of difficult sections of text where they should slow down and read more carefully. Another stamp in our system is the "Q" stamp, which is used for the teacher to include some direct reading comprehension questions for a specific passage or page in the book. Teachers can also include general sticky note stamps anywhere on the page for general comments.

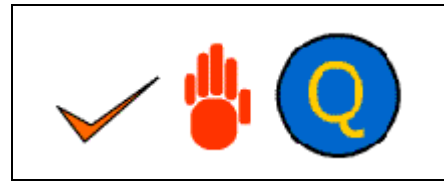


Figure 6: Current Teacher Stamps

Since a student user should generally examine or read the teacher annotations before beginning to read the book, teacher margin stamps are placed to the left of the text (we are currently assuming texts that are read from left to right). This visual indication will reinforce and remind students that they should read the teacher's comments or questions before adding their own annotations.

### Context Clues

A second tool for teachers is underlining. Although this may seem like a trivial feature, it is important as the teacher can use underlining to emphasize certain words within the text. Underlined words indicate to the students that if they're not sure what the word means, it is important that they look up the words in a dictionary. These could be vocabulary words or other words that the teacher thinks are important or difficult to understand. By underlining vocabulary words in a story, teachers can give vocabulary words in the context of the story, instead of detached list of words on a worksheet that may seem irrelevant to the students.

Child design partners suggested that it might be beneficial to provide a built-in dictionary functionality for these words, and this possibility will be examined in future versions of our annotation system.

### THE INTERACTIVE WORKBOOK

*(This section describes our first thoughts about the feature that will also be implemented this summer to include in the*

*final CHI paper. It will be an integral part of our annotation system.)*

The interactive workbook feature grew from two simple concepts: a note-pad upon which a student takes free-form notes for writing a book report or essay, and a worksheet that contains a series of comprehension questions that a student answers while reading a book. If students are taking general notes on an entire book, a sticky note will not give enough functionality, as the amount of text is limited, and a sticky note is associated with only one page of the book. A better solution is to select for the annotation system to go into split screen mode, with one side being the book and the other a note-taking page. This note page serves a very different purpose from the sticky notes that are added to a page: sticky notes are primarily in response to a certain passage of text, whereas the notes page includes the notes or thoughts about the entire book. Similarly, our child design partners felt having the worksheet of questions on a split-screen mode alongside the book while reading could help the students do their homework better.

From these ideas, we conceived of an Interactive Workbook. This tool also has a teacher and a student part. The Interactive Workbook Creator helps teachers make activities for their students to complete during the course of reading a book. The teacher can use this tool to compose such activities as pre-reading activities such as prediction sheets, reading logs, series of reading comprehension questions for a book, story-mapping pages, or book report or essay templates for students. Using this Workbook Creator provides a direct benefit over using paper workbooks, as it allows the teacher to create one version, and all of the students can easily get duplicate copies. In addition, these digital workbooks can include multimedia and hence be more interactive than paper alone could allow.

Future versions of the Workbook Creator could also contain templates from design work with teachers. These templates would reflect strategies that teachers typically use to help students learn while reading. The templates could then be customized for a specific book. In addition, there could be a library of Interactive Workbook pages for specific books. By using this library, new teachers could benefit from the experience of veteran teachers by using existing activities.

The student part incorporates the Interactive Workbook with the student annotation system. Students would receive any assigned Workbook activities from a teacher at the same time they receive the book with the teacher's annotations. The Workbook allows students to complete reading activities while reading a book by using a split-screen mode.

If a student is closely reading a book, and doesn't want to be bothered with the Workbook, the Workbook can be shrunk and hidden beneath the text. In this case, only a thin

strip would be visible, along the entire right side of the book page. At any point the student wants the Workbook to reappear, he/she would click on the strip to pull the Workbook back out. *(Will have a screen shot after we implement this)*

## **ANNOTATION INTERACTION BETWEEN STUDENTS AND TEACHERS**

We have implemented a rudimentary way to exchange information between teachers and students. The current system saves any annotations teachers make by automatically generating files. These files will then be distributed with the book to their students. This will allow the students to see and respond to their teacher's comments while reading, while creating annotations of their own. The teacher can then fetch these updated annotation files back from the student's bookreaders and analyze where the students had difficulty. However, currently the only way for teachers to view annotations from students would be to look at each student's version of the annotated book. We recognize the need for more sophisticated methods for distributing the annotation data from teachers to students and back. Future versions of the annotation system will introduce a seamless process to undertake this need.

Future versions of our annotation system will provide the teacher with a detailed analysis of all of the students' annotations, such as hotspots for troubling sections of the book and comments and questions asked by the students for their teachers to respond to during class. Visualization techniques may be helpful for teachers to see a whole classroom's annotations at once. We may want to include some way of compiling student answers for reading comprehension questions. It should be easy for students to get feedback on Interactive Workbook activities. In addition, it may be important to include some aspects of grading or assessment during these student-teacher interactions.

Simple quantitative compositions of student annotations, such as the average number of "clicks" or "clunks" on a page, are fairly trivial to implement and will be the first step to better understand how to provide teacher with meaningful representations of student annotations. Additional design work with teachers (*this summer?*) can address other ways to begin to focus on this complicated interaction process.

## **PRELIMINARY USER STUDIES**

While we have not yet conducted a formal user study, we plan to do this during the summer. During this study, we will work first with a group of teachers. *(We will get more feedback on the types of composing tools needed for teachers before conducting our teacher user study.)* During this study, we will work with probably six teachers (different from the teachers from whom we got design advice). The study will focus on the usability of the composition tool for how the teachers normally approach reading comprehension within their individual classes. We

also plan to get feedback on if they think this tool would improve their teaching style, how beneficial they think it will be to the students in their classes, and their general impressions and likes/dislikes of our original prototype.

We have gotten some initial feedback on an early version of the prototype from our child design partners. Four of the five children expressed that they thought the interface was really cool and that they liked the teacher functionality and hoped their teachers might use something like it in their classes. We got feedback that some of our icons were still confusing, that the interface still looked too childish, and that we may need to include a tutorial in how to use the tool

This summer we will also be conducting a user study with some children. We plan to work with a summer school or other summer reading group (at a library or Boy's and Girl's Club) to see how well the children can use the interface we created. The purpose of this study will be to test the usability of the student's annotation system, understand what features may still be lacking, and to see how children feel that reading on the computer screen will allow them greater flexibility than reading schoolbooks.

The study will be conducted over a period of time (a week or several weeks) (hopefully) during which children will already be learning reading skills and strategies. Our annotation system will then be introduced and explained, and the children will use the system to practice the reading skills and strategies being learned. We will compare the benefits of using a computer system over using traditional schoolbooks and comparing the affordances of each, in order to better understand the flexibility that the computer system allows.

## **DISCUSSION**

One of the most challenging parts of the design phase was to ensure that our system was able to utilize the ease of paper while offering all of the benefits of a digital medium. One such example is bookmarks. We were interested in all of the bookmarks being visible at all times so that the reader would be able to be able to instantly jump to whichever marked section of the book was wanted. We also wanted to give the bookmarks a digital enhancement: intelligence of what kind of annotations took place on that bookmarked page. Unfortunately, this data requires a substantial amount of screen real estate – so if there are too many bookmarks, they become useless. Perhaps providing a color-coded representation of the data instead of text would help. Zoomable sticky notes has a similar screen real estate problem, we didn't want to obscure text while making sticky notes, but to give them dedicated space may be impossible in many of the books in the current library. These issues will have to be dealt with in future versions of the annotation system.

One of the biggest obstacles left to face is to implement the Interactive Workbook in such a way that it will be natural and inconspicuous to take notes and answer questions

without disrupting the flow of reading. Since the keyboard is currently only used when a sticky note is visible and not during reading, it might be possible to simply pop up the workbook every time the keyboard is punched.

Building our annotation system on top of the current ICDL provided many advantages instead of choosing to enhance other existing proprietary book-readers, such as full control over the visual presentation of the reader, ability to make use of zoomable objects with ease, and the assurance the student readers would be able to use our program with no cost. However, using the ICDL presented several challenges. One such issue was the fact the books are not actual text, but instead scanned images of the physical copies of the books. Although we were able to come up with methods for the pivotal tasks of highlighting and underlining techniques despite this limitation, future functionalities we've discussed, such as a built-in dictionary, would require knowledge of what words the image actually represented. In this case, the books in the ICDL would have to text form using OCR. This is currently considered future work for the ICDL, but for our system we may need to do the conversion in a faster time window.

Our current implementation has several additional limitations. Lack of some key features such as an eraser tool to get rid of unwanted annotations is one example. Some of these limitations will have to be addressed before this work is truly publishable, but even at this point; we think that we have a very powerful educational tool. The ideas we expanded from working with the design team and with the teacher have resulted in an annotation system that we could easily imagine being used in a classroom setting in the near future. These tools do not just mimic or marginally enhance current classroom practices; rather they use technology to provide new functionalities that were not possible with paper books. So, while there are many limitations, it is clear that these prototypes are moving in the right direction for our user populations.

## **CONCLUSIONS**

The intent of building our annotation system was to augment the ICDL to better support learning. It is clear that poorly designed interfaces can impede productivity. It is also clear that that paper has been a successful instrument for annotation for many years. By providing the affordances of paper and augmenting them with benefits only possible in a digital world, we were able to design a powerful annotation system for students and teachers.

By working with middle-school children as design partners, we can be sure that our system addresses what students feel are requirements to enhance learning. By working with middle school teachers, we also were able to be sure that the features included in our final design were in accordance with effective reading strategies. These ideas became tangible when we built our interfaces to support them. Although we have had some promising results with

even our initial prototype, we will not be able to tell for sure how effective our system is until it is complete and extensive user studies are performed.

Annotation while reading is a proven technique to assist learning by engaging people in active reading. Our system incorporates proven reading strategies used in the classroom into an interface whose simplicity is comparable to paper. In addition, the functionalities that we have provided for students and teachers allow them to interact with the text and with each other in ways never before possible in a school setting. Due to these factors, we believe our user studies will show that not only does our system give a clear advantage over paper solutions, but that this system clearly provides a learning advantage in the classroom. (*Once we have done our user study, our findings will be reflected here.*)

#### FUTURE WORK

We plan to continue to work with teachers and our intergenerational design team to get additional feedback about the system. Our future work will explore ways to further develop the Interactive Workbook. We think there are many interesting research areas to explore in the Interactive Workbook, from the educational technology aspect and the people, papers, computers aspect. In addition, from design sessions this past year, we have identified many additional functionalities, including translation and other aspects related to reading foreign language texts and exploring other ways to cross-reference text when preparing school reports. In addition, the domain of teacher tools needs to be explored in much greater detail.

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