Collage: A Presentation Tool for the K-12 Classroom

ABSTRACT

We present *Collage*, an application designed specifically to support a K-12 teacher in a classroom equipped with a single PC and a projector. Initial ethnography of schools suggested that a tool that offered simplicity, enabled display of images and allowed incorporation of existing paper material (such as textbooks) would be most helpful. So, Collage is at heart a simple media viewer, but adds a handful of features that allow teachers to interactively display textbook materials during instruction.

The only significant "competitor" to Collage is PowerPoint, which despite its non-education-focused heritage, has penetrated an impressive number of schools. In our 3-month field deployment, teachers reported that in comparison to PowerPoint, Collage was easier to use, took less preparation time per class, and enabled the kind of impromptu flexibility they sought during class.

Author Keywords

Computers, education, presentation tool, K-12.

ACM Classification Keywords

H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces - User-centered design.

INTRODUCTION

"We need something that helps students visualize things and [that] works as a blackboard at the same time."

> - Assistant Teacher, Govt. primary school, Bulandshahar, India

The use of computers and digital projection systems is now becoming increasingly common in schools across the world, even in the developing world. One question that immediately arises is, "How can a single PC and a projector support a teacher in the typical developing world classroom?" The question is particularly pertinent for K-12 classrooms, where, despite the increasing rate of adoption of projectors, research on its effective utilization is practically non-existent.

While there might be many creative uses of such a system, our focus here is on one aspect – that of designing

appropriate software to assist K-12 teachers to conduct computer-supported instruction in the classroom. To the best of our knowledge, there is no software that has been designed specifically for this purpose, although it is claimed that general-purpose presentation tools – like Microsoft PowerPoint – are used by over four million K-12 teachers across the world for instructional purposes [1,11].

Numerous studies document the positive effects of using PowerPoint-authored slides in the classroom (see [15] for a good survey), but such studies exist only for undergraduate education, and evidence to support the use of PowerPoint for K-12 is still very limited. In fact, there is a rich body of literature which critiques the deployment of PowerPoint as a classroom teaching tool, and systematically argues why PowerPoint is *not* the right medium to teach students with. Arguments against PowerPoint range from criticisms of specific features of the tool (like custom animations, and bullet points) [24,6] to attacks against its overall design which is claimed, by many, to suppress expressiveness and spontaneity of teachers and reduce interactivity in the classroom [14,24,16].
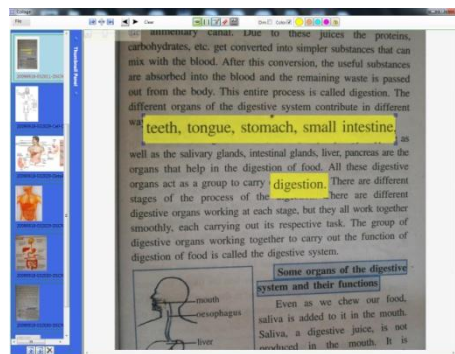

Figure 1: A screenshot of Collage.

In this paper, we present a new software tool called Collage, which has been specifically designed for K-12 teachers in developing world schools and is meant to assist them in using a digital projection system for classroom teaching. Based on ethnography across 11 schools in India, we believe we cannot expect teachers to make dramatic changes to their standard pedagogical styles, just by introducing new technology. So, instead, Collage seeks to integrate itself within typical classroom pedagogy. In terms of its overall design, Collage is more like a media viewer than PowerPoint, allowing spontaneous display of media, and minimizing preparation work. We additionally support a few features which are absent in traditional media viewers, like the interactive display of textbook scans and images, and the ability to overlay media elements on each other.

We have successfully deployed and tested Collage in three K-12 schools (two public, one private) located in rural and suburban Karnataka (India). The teachers who have used Collage during instruction almost consistently report that it is easier to prepare digital presentations using Collage than using PowerPoint, and that Collage allows them more flexibility while presenting digital materials in the classroom. In addition, both teachers and students rate Collage as being significantly better-suited for displaying visual content in the classroom than PowerPoint.

RELATED WORK

Technology for Education
The idea of using computing technology as a teaching tool is not new and projectors, in particular, have been used in K-12 classrooms for at least a decade [10]. There has been a reasonable quantum of research on the benefits of equipping schools with computers, ranging from impact assessment of technology immersion in schools [21] to that of providing laptops to all teachers in a school system [9]. Such work tends to treat the technology used in schools as a monolith and typically ignores the question of how best to *construct* technology in order to suit the school environment. It is also difficult to isolate the effects of individual components of the system (e.g., a specific software tool or a specific pedagogical style) in such interventions. Banerjee *et al.* [5] consider the question of technology deployment in developing region schools and provide evidence which suggests that the quality of human capital is critical in influencing the impact of any technological intervention in such schools.

A specific classroom technology that has attracted considerable interest, particularly in developed region schools, is the interactive whiteboard (IWB). Higgins *et al.* provide a comprehensive overview of research on the impact of IWBs in schools and teachers' and students' perceptions of the technology [13,12]. Even with the prevalence of this technology in developed world schools, to the best of our knowledge, there is no research on user-centric design of presentation software for IWBs, of the nature that we undertake in this paper. The presentation tool that we describe has been designed while taking existing classroom behaviors and teachers' preferences into consideration. Although this tool has been tested with a standard data projector only – for reasons of cost and scale – it is also compatible with IWBs (provided they use the requisite operating system).

Presentation Tools for K-12
The use of digital tools is prevalent in K-12 classrooms in the developed world, and is on the rise in the developing world as well. Still, research on the design and evaluation of appropriate presentation software for the purpose of *classroom instruction* in K-12 is, to the best of our knowledge, non-existent. Presentation tools commonly used in the K-12 classroom range from general-purpose slideware technology like PowerPoint and Apple's Keynote software [21] to a variety of media viewers [9,13,21]. Based

on current knowledge [1,11,12,13,15,21], it seems safe to assume that PowerPoint is the most-heavily utilized software presentation tool in today's K-12 classrooms, although currently we do not know of any documentation of global comparative statistics. PowerPoint's usage in education is now so entrenched that some papers on the subject of classroom technology use its name interchangeably with the term 'presentation tool' [15].

Presentation Tools for Higher Education
There has been some work on designing special-purpose software presentation tools for the undergraduate classroom. Perhaps the work that is most closely related to ours is that on Classroom Presenter (CP) [4,3], a tool meant to support ink-based interactions on PowerPoint slides, intended to be used in a classroom environment. Our tool bears a strong resemblance to CP, though there are some key differences, too. First, the context is very different – our focus is primarily on K-12 classrooms and the design process of our tool has taken this into consistent consideration. Second, CP is designed mainly to support digital inking on PowerPoint slides, whereas our goal is more general – design of presentation software that supports pedagogical practices in a K-12 classroom and that suitably addresses teacher preferences. Third, owing to a different design process and one that is for a specific context, the feature set we have arrived at is quite different from that of CP, although there are quite a few overlaps. Fourth, and perhaps the most important, CP is a tool that operates on PowerPoint slides, whereas our tool accepts anything that can be represented as a digital image (or a video) as input. (This, in particular, includes PowerPoint slides.) Lastly, CP supports various multi-user interactions (e.g., a facility for capturing student feedback digitally and one for distance learning) which our system currently lacks but may incorporate in future versions.

Presentation Tools that Integrate Digital and Paper
The idea of using paper content in electronic presentations, like we do in our presentation tool, has been considered in past work. The document camera or visualiser [2] is a tool that allows instructors to digitally project paper-based content (from textbooks, hand-made slides and notes) in real time and provides basic functionalities like zoom and perspective variation. The technology is becoming increasingly prevalent in school and university classrooms [2]. Even with its advantages over overhead projectors, the visualiser is limited in that it does not support integration of paper with digital multimedia; in the tool we describe in this paper, such a facility is supported.

Other techniques to incorporate paper in digital presentations include the use of barcoded paper cards for slide navigation [19] and of interactive paper to annotate presentations in real time [22]. Both these techniques have been designed to be used with PowerPoint-authored slides only. Neither has undergone the type of user-centered iterative design and development that we undertake in this work.

Presentation Tools and Pedagogy

There has been some work studying the pedagogical benefits of software presentation tools but most of this work has been in the context of PowerPoint-based instruction for undergraduate classrooms. Various experimental studies have shown that instructing students using PowerPoint slides increases their engagement levels (when compared with instruction using tools like overhead projectors and chalkboards) but the difference in learning outcomes vis-à-vis other tools is only marginal and often insignificant [15]. Studies have also shown that the learning benefits of presentation software can be greatly improved by enabling post-instructional access to the content of the presentation [23]. For K-12 education, there is research which shows that the use of PowerPoint can be enjoyable for teachers but compared with the use of chalkboards, it leads to no noticeable change in students' learning outcomes [8]. No studies comparing the pedagogical value of PowerPoint with that of other presentation software are currently known.

INITIAL ETHNOGRAPHY

As a precursor to the process of designing our software tool, we conducted an investigation of current practices in K-12 schools in India, specifically with respect to the use of instructional technology. We visited 11 schools (9 public, 1 private, 1 semi-private) in and around two cities in India – Bangalore and Pune, interviewed 24 teachers and conducted 21 classroom observations (covering 14 different teachers).

Since our main goal was to understand how teachers used or might use technology for instructional purposes, we worked closely with partners who had experience providing technology support to schools. All public schools in our sample were identified with the help of such partners. The remaining two schools were reached through other non-profit partners.

The schools we chose were all equipped with a computer lab with at least 6 computers per school. The private school had the maximum number of computers – 40, for a school-strength of 700. Availability of additional hardware varied a lot: 6 out of the 9 schools possessed a digital projector, which was meant to be shared by all teachers in the school. (The private school was the only one to have 2 projectors; the rest had exactly one.) The remaining 3 schools did not have a projector, but they all had a TV of size at least 21". Internet facilities were present in 2 schools. There was no school with interactive whiteboards. (This technology is still scarce in Indian schools.)

The teachers we spoke with came from a diverse set of backgrounds: they spoke at least 5 different languages (although most were comfortable in English), and their teaching experience ranged from 2 years to 26 years. Teachers taught a variety of subjects including language, mathematics, science, social science, environmental science, home science and computers, some teachers covering multiple subjects at the same school. There were 13 secondary school teachers (grades 8-10), each holding a bachelor's degree in education (B. Ed.) from a deemed university, and sometimes even a masters degree in their respective area of specialization. The rest were primary and middle school teachers (grades 1-7), with a bachelor's degree in arts or science. Teacher salaries were in the range of USD 150 – USD 400 per month.

The interview sessions were typically one-to-one, open-ended conversations with the teachers and most of the questions we asked were around their current use of computing technology and the motivations behind the same. We attempted to make classroom observations as unintrusive as possible, and abstained from any interactions with the students or the teachers while making observations. 2 out of the 21 classroom observations were of classes involving the use of digital technology; in both, teachers used PowerPoint slides as a presentation tool. In sum, the interviews and classroom observations accounted for at least 50 hours spent in the field.

Findings

The most important observation we made during our school visits was the large gap that existed between the number of classes in which teachers used computing technology as a teaching aid, and the number in which they did not. At least 90% of all classes in the schools reportedly involved using the chalkboard as the primary presentation tool and most of the tools teachers used besides the chalkboard were made of paper, including things like textbooks, student workbooks, posters, flash cards and occasional paper handouts. Computers, when used, were used primarily to promote student self-learning or else to teach students how to use the equipment. For the chalk-and-talk classes, teachers treated the content of textbooks as the main source of information: all teachers interviewed reported to be preparing their classes based on the content of the textbooks, and 11 out of 21 classes observed by us made explicit use of textbooks both by the teacher and the students in the classroom. In 19 of the 21 observed classes, teachers made use of the chalkboard; in the remaining 2, they conducted a PowerPoint presentation.

Teachers' desire to use computers for classroom instruction and the actual usage for this purpose never matched. Six out of the 24 teachers reported not to have used computers for instruction at all, even though all of them had almost equivalent access to it. Every teacher we spoke to said that s/he would like to be able to make more frequent use of computers for teaching than s/he currently did. Only 4 out of the 13 teachers who had access to projection technology reported to be using it more than 4 times in a year. One English teacher said that she would like to use a computer (with a projector) to teach her students once a week, but admitted that she did not do this even once in the last one year.

The under-utilization of technology by teachers was rarely due to non-availability of functioning hardware or the difficulty of sharing it with other teachers (although the

former was an issue in some cases). The main reasons teachers gave to explain the situation were (a) lack of proficiency in using computers; and (b) lack of sufficient time to prepare digital content that is most relevant in their context.

The first reason given by the teachers was often more critical. Most of the teachers we spoke with had very limited access to computers in their everyday lives (only 7 had a PC at home), and as such, were not confident technology users. One issue that seriously affected their comfort level with computers, particularly in the context of using general-purpose software like PowerPoint, was their lack of expertise with typing. 13 out of the 24 teachers we interviewed explicitly stated that they were not satisfied with their typing abilities. 9 out of the 13 PowerPoint users stated that typing was a deterrent in their use of slideware for classroom teaching.

The second reason amongst these was also important, and intricately related to the first one. A majority of the teachers expressed the desire to be able to prepare and present content of their own choice to students, but complained that they could never find enough time to be able to do this regularly. 13 out of the 24 teachers interviewed were familiar with PowerPoint and reportedly liked to use it for instructional purposes. But only 2 of these admitted to have made more than 4 PowerPoint presentations for their students in the past one year. In an independent survey of 41 school teachers (mostly from public schools) across India, we found that teachers who wish to use PowerPoint, on average, spend at least 5.5 hours preparing a *single* PowerPoint slide deck for a 40-minute lesson. This is more than 10 times the amount of time required to prepare for a normal (technology-void) class, as reported by them. As one teacher in our current study commented

> I don't use PowerPoint in class, [although] I used it in my company where I was employed earlier. Time factor is the main reason for us.

Ten of the schools we visited had received CDs with multimedia-based educational content from different vendors. Teachers were divided on their opinions of these CDs and their potential value for classroom instruction. Some expressed unequivocal liking for such content, particularly for primary-grade content developed for self-aided learning, while some complained that they found it difficult to make the content of the CDs appear relevant to the standard classes where content was driven primarily by the textbook and activities done on the blackboard. One teacher specifically remarked that multimedia CDs donated to his school did not leave him any flexibility to modify content so as to fit his preferences, and that he was creating his own digital image collection using computing resources at a neighboring Internet cafe.

When asked about their motivation to use technology for instructing students (or their interest in it, otherwise), teachers universally stated that computers are a useful tool to help students visualize curricular concepts better. Some

more specifically stated that they helped visualize "hard concepts" better. This was evident in the 2 PowerPoint presentations we witnessed: Over 75% of the slides teachers used in these presentations contained at least one picture and the use of text was minimal (at most 33 words in a slide)[1]. At one school that was about to be donated a digital projector and laptop, two teachers stated that they would use the new equipment only to show pictures and videos to students. Teachers' interest in using computing technology for presenting visual content was palpable: there were at least 8 teachers in our sample who, despite not having access to the Internet at home or in school, reported to have spent time in cyber cafes only to gather images for their classes. One of these teachers reportedly spent 2 hours in a café to download pictures for a single PowerPoint presentation. All but 3 of the teachers who had used computers for presentations reported to have obtained their visual materials from the Internet. The rest used multimedia CDs given to them from a content donor.

Design Principles for a New Presentation Tool
Based on information gathered during our field visits, we defined the following design guidelines for a presentation tool for K-12 teachers:

1. ***Keep it Simple***: The tool should be easy to use and the time required to prepare presentations should be minimal. Utilization should not require mastery of typing skills. All components of the tool should be implementable on a standard PC setup and a projector.

2. ***Display Images:*** The tool should facilitate display of multimedia, in particular, digital images.

3. ***Exploit Paper***: The tool should help teachers exploit content that they already use in everyday classes, which, in particular, includes content in curricular textbooks.

COLLAGE – THROUGH THE DEVELOPMENT PROCESS
Unlike most commercial presentation tools, Collage is a tool that has been designed with a specific application in mind, viz. instructional support for K-12 teachers. Since it is targeted at such a specific audience, we have strived hard to address the needs of our target users in making various design decisions. The tool has undergone an iterative development process over a period of one year, and testing in our first pilot school – referred to as school A, henceforth – began right in the first month of the development cycle. This school was one of the schools selected in our earlier ethnographic sample and has the following characteristics – secondary school in rural outskirts of Bangalore, 8 teachers, 147 students coming from marginalized communities (parents' income less than 2 USD a day), Kannada – the

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[1] We analyzed more than 10 PowerPoint slide decks made by teachers in these schools and observed the same pattern in all these decks.

official language in the Bangalore region of India – as the medium of instruction, computer lab with 10 computers, printer, scanner and video camera. A digital projector was not present at the school when we began our visits, but was acquired within 3 months of our first visit.

Two teachers at the school – a literature teacher and a science teacher – contributed extensively to the development of our tool, both in terms of trying the tool in their classes, and in terms of giving us critical feedback. Both these teachers hold a master's degree in their respective area of specialization from a deemed university. Both had reasonable familiarity with computers, and reported to have conducted up to 4 PowerPoint presentations in a year, through a standard PC and 17" monitor (no projector). A third teacher at the school also used the tool in two classes, but her involvement in the feedback process was relatively limited.

The First Cut – A Plain Image Viewer
Early on in our fieldwork, it became evident to us that teachers' main interest in using technology in the classroom was to display digital images to students. This suggested that a presentation tool for the K-12 classroom should look more like an image viewer than like a variant of PowerPoint. Indeed, the first prototype of our tool was *exactly* an image viewer – all it did was enable users to load a collection of images into memory, to view them in an arbitrary order (using a standard thumbnail-driven interface), and to do basic operations like deletion and reordering of pages.

This idea, though seemingly trivial, had an interesting implication on the subsequent design of our tool. Emulating an image-viewer meant that there would be no way to *author* content in our tool, but only to display it. Preparing presentations would essentially correspond to "collecting" images (which have been authored independently), and storing them in a suitable location, from where they could be easily accessed later on in class. The notion of a digital "slide" and the process of designing and populating slides with images and other materials, ahead of class, got precluded.

Incorporating Paper
Arguably, displaying images is not the best utilization of computing technology, and even though the teachers we had interviewed used PowerPoint primarily for image display, they *did* incorporate text in their presentations, too. Besides, research in educational psychology shows that images by themselves are not sufficient to induce significant learning; text must suitably complement them for this [18,25]. We needed a way to facilitate presentation of text in our tool.

The challenge in front of us was that we needed to incorporate text without requiring the teacher to spend much time using the keyboard to prepare presentations. We used a straightforward solution for this: teachers would incorporate textual content in the tool by digitally *scanning*

or *photographing* content that has already been developed on paper. This could include content that is pre-determined (like a page in a textbook) or that which is specifically authored by the teacher for the purpose of classroom instruction (like a science diagram drawn on a piece of paper).[2] We used a standard camera and scanner to digitize paper materials and not a document camera [2], since the former tools are relatively inexpensive and more prevalent in Indian schools. The idea of incorporating paper-based content did not require any modification to the image viewer we had developed, but it did prove very critical in informing future design decisions.

Adding Features
When we demonstrated our prototype to the teachers at school A, they were not impressed. Although the idea of projecting textbook scans did appeal to some, using a projector in the classroom only to run an image viewer seemed like an under-utilization of technology. The science teacher, for example, expressed a preference to use PowerPoint because it allowed him to interact with the content during presentations, which our tool did only very limitedly. We started seeking ways to add interactivity to our image viewer.

One particular feature which we incorporated in it was *rectangle selection*: this feature enables users to identify rectangle-shaped regions inside images – referred to as 'pages' in our system – through a natural click-and-drag process to identify corners and to arbitrarily resize and move the region thus identified (again, by clicking and dragging)[3]. Later, we incorporated the option to color such selections – referred to as *page elements* – differently (see figure 2) and an option to "dim" the background page. The rectangle selection feature provides teachers a simple way to highlight regions within a page (e.g., words or phrases in a textbook page could be highlighted), and to focus students' attention on such a region via options like coloring, background dimming and resizing.

We included a *zoom* facility (using a physical zoom-bar as well as a scroll-wheel-driven shortcut) and a facility to digitally *ink* on pages. Enabling meaningful ink interactions with the content necessitated the use of additional hardware – we used a graphics tablet and stylus attachment – in the

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[2] Scanning or photographing paper materials requires an extra piece of hardware – a scanner or a camera – to be present in the school. Such equipment was already present in all the schools that we tried our tool in. While photographing paper may not be the most optimal way to digitize it (in terms of the resultant image quality), it is a more flexible and efficient approach for this purpose. In ongoing work, we are trying to address this trade-off between photographing and scanning paper materials.

[3] The original page remains intact, while a fresh copy of the selected region is created as a layer on top of it. This is in contrast with some other implementations of rectangle selection, e.g., in Microsoft Paint.

system and some extra training effort[4]. But the gains from incorporating digital inking were tremendous. Ink helped teachers create content spontaneously as images were displayed on the screen, which closely emulated their interactions with the blackboard in regular classes. The benefits of using digital ink in university classrooms have been well-documented [4, 3] and our experiences suggest that these benefits carry over to the K-12 environment.
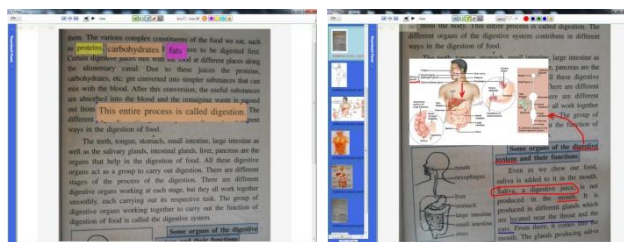

Figure 2. The left figure illustrates the rectangle selection feature; the right one illustrates image overlay and inking.

Other interactions were implemented but eventually got cut due to lack of sufficient uptake. We considered, and partially implemented, the option of hyper-linking parts of pages with each other (or with parts of other pages) and hyper-linking a part of a page with an external resource (e.g., linking a word inside a textbook with a media file). Such features are common in presentation tools, although how often they are used in actual presentations is not well documented. In our case, hyper-linking gained absolutely no traction with the teachers – the time required to set up hyperlinks prior to class was much too high for the potential benefit during class and the random-access model of our image viewer appeared to be sufficiently convenient. We also implemented a feature to automatically detect word boundaries inside pages with textual content and click-facilitated selection of words (in absence of good OCR tools for Indian language scripts, we were compelled to implement our own word identification facility). This feature could not match up to the rectangle selection feature in terms of accuracy and flexibility, so, teachers continued to use the latter for all their highlighting needs.

Features Based on Teacher Feedback
While teachers under-utilized some features we implemented, they suggested some new ones, too. Based on teacher feedback, we incorporated a feature to interactively play *video* files. Videos are treated in a similar fashion as images in our tool: each video is a "page" which can be displayed in the page viewer just like other pages. Video pages implement some standard video-specific functionality like play, pause and rewind, and also admit other interactions like rectangle selection, zoom and inking.

One teacher suggested that we implement a feature to enable *overlaying* an arbitrary image on top of textbook pages during presentations. We implemented a generic functionality to overlay arbitrarily many pages on to any given page. In particular, both the page being overlaid and the page overlaying it could be either an image file or a video file.

We implemented a functionality to *save* page collections in the form of "page decks". A page deck records all page elements and ink strokes that teachers create during presentation. Finally, several teachers (including others who tried it in other schools later on) suggested that a *textbox facility* be available, as an alternative way to annotate pages, which we also implemented.

Features That Evolved in the Field
Although the digital inking feature enabled teachers to create content spontaneously in class, it was restricted to be performed only within the boundaries of the page viewer. Teachers often felt constrained to ink long phrases of text, especially when the page had limited white space. We implemented a feature that splits the screen vertically into two parts, the left part displays pages as before while the right part – the *whiteboard* – becomes a scratch space for creating fresh content. We also implemented ways to create page elements in this space, to move page elements back and forth between the two parts of the screen (via a drag-and-drop protocol) and to transfer all contents of the whiteboard into the page viewer.

This simple idea opened the doors for a lot of unanticipated creative activity around our tool, which we discuss in the next section. The whiteboard became a real-time "content creation zone" for teachers where they could assemble elements from different pages (textbook pages, images, or videos), insert entire pages, perform annotations and organize content in different orientations, based on the immediate needs of the lesson. The spontaneity with which teachers used this feature in class was reminiscent of the way collages are created on paper, which led us to the name we eventually chose for our tool.

One final feature we implemented was *page occlusion*. Teachers were seeking a way to use PowerPoint-scripted slides (suitably converted to images) in our tool, while animating the bullet points one by one, top to bottom. In response, we built a rectangle drawing facility in the tool. The intended usage was to draw rectangles to cover pages and then to re-size these rectangles so as to reveal the underlying content gradually, much like how transparencies are displayed through overhead projectors. (See figure 3.) This was our own crude approximation of PowerPoint animations, and is now a permanent fixture in our tool.
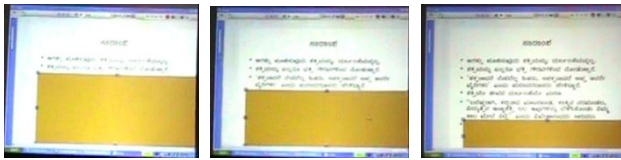
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[4] The use of Tablet PCs and interactive whiteboards was avoided in order to minimize the cost of our system. (Such equipment is still prohibitively expensive for a majority of schools in India.) The cost-usability trade-offs for graphics tablets and Tablet PC's in lecturing environments have been studied in the past [17] and for resource-constrained environments like ours, graphics tablets are the optimal choice.

Figure 3. The occlusion feature being used in a literature class at school A.

COLLAGE - THE FINAL PRODUCT

Overall, Collage went through a series of at least 50 iterations and in each iteration, we either incorporated a fresh feature based on teacher feedback, or improved on an existing feature, or deleted an existing feature, or sometimes, even introduced major changes in the internal architecture. At the end, we converged on the following set of interaction capabilities for our tool: (a) rectangle selection; (b) digital inking and erasing; (c) image overlay; (d) occlusion; (e) textboxes; (f) whiteboard; and (g) a functionality to create, save, and open page decks. Besides these features, the tool implements the basic functionality of a media viewer, including zoom (zoom on videos is also implemented) and the functionality to reorder/delete pages and to access them in random order. Collage has been implemented to run on the Windows operating system.

DEPLOYMENT AND RESULTS

Collage has been deployed in 3 schools in the Bangalore region of India. Deployment in two new schools (besides school A) began in August 2009. Both these schools were part of our initial ethnographic sample of schools. One of these schools (school B) has the following characteristics: K-12 school in suburban Bangalore, some of the most under-privileged children from Bangalore city, 700 students, over 35 teachers, well-resourced relative to the average public school in India, English medium, computer lab with more than 30 computers, Internet connection, scanner, printer, video camera and 2 digital projectors. We worked with 3 teachers in this school (out of a total of 40), covering grades 5-8, and subjects English and science.

The other school (school C)'s characteristics are as follows: upper-primary and secondary school in rural Bangalore, central-government funded boarding school, caters to students from rural areas around Bangalore, 20 teachers, 400 students, modest computer lab with over 20 PCs (but old software e.g., Windows XP on only 2 machines), an Internet connection and a single digital projector. One teacher of English, who teaches grades 7 to 10, has tried our tool in the classroom.[5]

All teachers who have used Collage in their classes (2 from school A, and 4 from schools B and C) are familiar with PowerPoint and reported to have used it for instruction at least 4 times prior to our intervention, although proficiency levels varied a lot. Most of these teachers are not avid

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[5] At least 10 other teachers at schools B and C expressed interest in Collage (and have interacted with the tool as part of an orientation we conducted) but are yet to try it in the classroom.

computer users, none but one has a PC at home, and none but one uses a computer for more than 5 hours in a week. (There was one teacher who reported to be using PCs for more than 2 hours a day, but she was the computer lab manager at school B.) Still, training teachers in schools B and C to use Collage required very minimal effort: we spent at most 2 man-hours per teacher, and this included sufficient practice time for each teacher.

One challenge, of course, was the graphics tablet, which none of the teachers had encountered before our intervention. Teachers requested extra time to practice with the tablet, and could not gain sufficient confidence in using it in just 2 hours. However, 3 of the 4 teachers who were newly trained *did* use the tablet in their very first class, which suggests that hesitation to try the new piece of hardware in front of students was not significant.

Teachers were convinced that Collage is easier to learn than PowerPoint. The teacher at school C – who had undergone training in PowerPoint for 12 days three years before – specifically said: "Collage is certainly much easier to learn [than PowerPoint]". The literature teacher from school A – who spent 3 months training high school students in PowerPoint usage prior to his teaching assignment at school – said, "I think anyone can learn it in one day. But PowerPoint, I think, a person would take 15 days to learn." The task of evaluating the precise efficiency of training the average teacher to use Collage (up to a point where she can comfortably conduct classroom presentations) is fairly non-trivial and as such, we have postponed it to future work.

Usage

In all, Collage has been used in at least 43 different classes across the 3 pilot schools, totaling more than 40 hours of real classroom usage. This excludes usage outside class for the purpose of practice and for class preparation. Most of the usage (at least 39 classes) is accounted for by school A, where teachers have used all past prototypes of the tool. In schools B and C, each teacher we trained has used Collage in one class of 40 minutes each.

This rate of usage may appear discouragingly low, but we must view it in the context of our target environment. As already noted, these teachers are not frequent users of computing technology, and their use of technology for classroom teaching, in particular, is extremely sparse: all, but the computer lab teacher at school B, had made less than 5 PowerPoint presentations in the one year preceding our intervention.

Given these conditions, we find it interesting that the usage of Collage in school A has been sustained at the rate that we have found it to be. Both Collage users in the school are using the tool currently without our visiting them for it (at least 5 such classes reported), and they have started training other colleagues at the school in the tool's usage.

One reason we feel the tool has gained sustained adoption is that Collage affords teachers the ability to easily transition

from a blackboard and textbook-centric teaching model to one that involves more multimedia. Different teachers go to different lengths and in different directions from this but in what we have observed till now, teachers carry over a lot of their regular classroom behavior easily into the Collage-supported model of teaching[6]. We illustrate this with some key usage patterns we have seen during our classroom observations.

Usage Pattern 1 – "Mix as you teach"
Perhaps the most consistent theme we have noticed amongst teachers (both old and new users) is that they all have a tendency to "mix" different forms of content as they teach using Collage. There are two simple provisions in Collage which facilitate mixing of content: the whiteboard (using which teachers can assemble elements of different pages in one space); and the page overlay feature. Since the time the features were implemented, at least one of them has been used a non-zero number of times in almost every class we observed. The *only* class in which *neither* of the features got used was conducted by the teacher who was the top user of PowerPoint in our sample.

The whiteboard, in particular, is a heavily-utilized facility. In an analysis of 12.6 hours of usage data[7] covering all 6 teachers, we found that teachers use it at the rate of 5.03 episodes (window of opening and closing the whiteboard) in an hour. Each teacher has invented his or her own unique style of using the whiteboard. The science teacher in school A often uses it to display words and phrases extracted from textbook pages alongside relevant images (figure 4(a)). The same teacher sometimes assembles key words from the text to form a "word wall" as shown in figure 4(b). A similar word-walling activity was performed by the English teacher in school B in the sole class she conducted using Collage (figure 4(d)). The English teacher at school C used the whiteboard to display a scan of his hand-written notes, as he displayed a textbook scan on the left.

The literature teacher at school A has a particularly interesting style: as he teaches a chapter from the textbook (displayed in the page viewer), he generates a glossary of words for the students on the whiteboard, as shown in figure 4(c). The glossary-generation process involves a fairly long sequence of user interactions but the teacher performs these actions with a level of deftness that one might expect only from an expert computer user. Besides, he performs these actions *as* he is discoursing the lecture. What is most interesting is that he creates similar glossaries on the *blackboard* in regular (non-tech) classes, although

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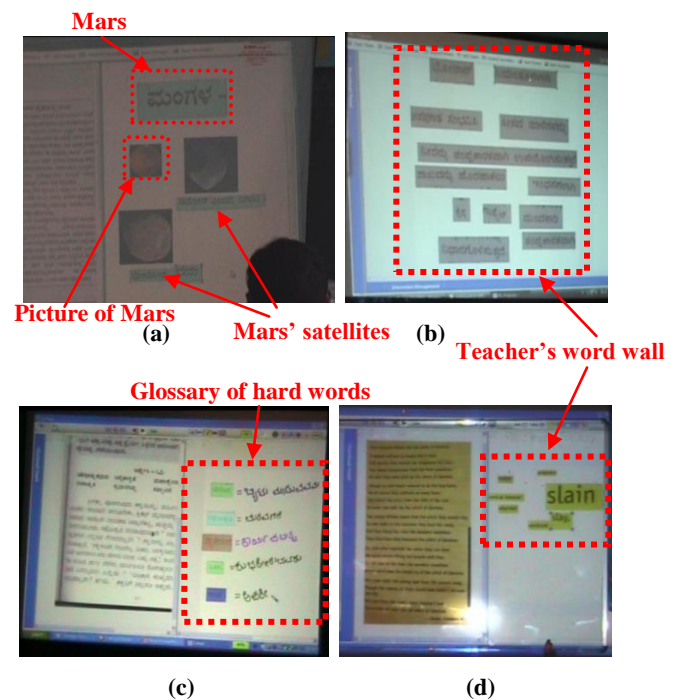there, he is compelled to do it without any textbook scan on the side.

Figure 4. Teachers have invented their own pedagogical styles of using the whiteboard facility during classes.

Usage Pattern 2 – "Clean up the board regularly"
An equally consistent theme we have observed is that teachers tend to erase the contents of the whiteboard after having filled it for any non-terminal segment of their class. In Collage, teachers have the choice to transfer contents of the whiteboard into the page sequence in order to save it for future referral. But they don't exercise this choice at all: none of the 6 teachers transferred whiteboard pages into the page sequence even once, despite having been demonstrated the feature. The only time teachers do *not* erase the whiteboard is at the end of the class i.e., the last whiteboard page created does not get erased. There is a remarkable resemblance between this behavior and the manner in which teachers treat the blackboard in regular classes. Even giving the teachers choice to preserve content created on-the-fly, they prefer not to tread that path.[8]

Usage Pattern 3 – "Rework your plan as you teach"
A third theme we have been observing is that a lot of the page changes teachers perform in class are between non-consecutive pages: In 632 minutes of Collage-supported class time at school A, we observed 215 page change

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events, out of which 121 (i.e. 56%) events corresponded to non-consecutive pages in the page sequence. This is surprising on one hand, given that these teachers take care to order their pages to fit their preference before going to class, but also not too surprising since it is only natural for most teachers to improvise and switch contexts as they teach [20]. During regular classes, too, teachers tend to go back and forth between various portions of the blackboard without having explicitly "planned" for it.

The newly-trained teachers did not make as many improvisational switches as the others: only 15% non-consecutive page changes, on average. Two teachers did not make any non-consecutive pages changes at all – one of them used only 6 pages in her presentation (the smallest ever for Collage), the other – the computer lab teacher at school B – is the top user of PowerPoint in our sample.

Evaluation
To understand the benefits and downsides of Collage, we collected qualitative feedback from the six principal users of the tool and conducted a preliminary examination of students' perception of Collage-driven presentations. Our evaluation tools were focused on assessing teachers' and students' perceptions of Collage vis-à-vis their perceptions of PowerPoint, which is the only other alternative for presentation software available in these schools. Feedback of teachers was collected using a combination of semi-structured interviews (lasting up to an hour each) and a written questionnaire wherein teachers compared Collage and PowerPoint on 8 parameters. The results of the questionnaire are shown in Table 1. The results of the interviews are described next.

Flexibility of presentation
Teachers consistently reported that Collage affords them greater flexibility when presenting digital content in the classroom, and enables them to digitally mimic actions they perform in regular chalk-and-talk classes. When asked about their preferences for individual features in the tool, teachers voted strongly in favor of "whiteboard", "rectangle selection" and "inking" (in that order, on average). As one of the teachers at school B commented:

> I thought I could use the whiteboard spontaneously [in class], even though I had not pre-prepared [what to use it for].

Another important aspect, as reported by teachers, was that the tool affords them the ability to be spontaneous in class while also providing a rich set of possibilities to "mingle" content. As a teacher at school A put it,

> Collage helps me correlate two types of information. [I can show] pictures on one side and equations on the other side. I can show videos alongside textbook pages. This kind of mixing of different materials helps children learn better.

Question	Rating
It is easier to create digital presentations using Collage than using PowerPoint	3.67
It is easier to present digital content to students if I'm using Collage than if I'm using PowerPoint	2.83
Collage allows me more flexibility while creating digital presentations (i.e. I can make more changes to content and/or make changes more easily if I create them using Collage, as compared with PowerPoint)	4.33
Collage allows me more flexibility while presenting digital content than PowerPoint	4.33
Collage is a better tool for presenting images/videos to students	4.33
Collage is a better tool for presenting text to students	3.5
Students in my class will learn better if I present content using Collage than if I do the same using PowerPoint	4
For a teacher who wants to use digital content for classroom teaching, Collage is a better tool than PowerPoint	4

Table 1. Teachers' perception of Collage vis-à-vis PowerPoint. Rating indicates teachers' responses (n=6) on a 5-point Likert scale. In the questionnaire, the order of terms "Collage" and "PowerPoint" was suitably counter-balanced to remove ordering effects.

Ease of content preparation
One of the key benefits of Collage with respect to PowerPoint that teachers consistently reported was efficiency: 5 out of the 6 teachers reported that it took them less time to prepare presentations when using Collage than when using PowerPoint. (The sixth teacher was neutral about it.) The science teacher at school A commented,

> Earlier I had to spend at least two hours making PowerPoint presentations; with Collage, I can do it in 20 minutes.

Teachers attributed the savings in time to a combination of two factors – the avoidance of effort required to prepare and format slides, and the efficiency gained by scanning paper materials. Teachers at schools B and C said,

> What I like is that we need not spend time making slides (cutting, pasting, slicing etc) in Collage. Everything can be shown raw. .. .. In PPT, you need to make a lot of .. you know .. formatting changes [before going to class]. Here, the only job you need to do is scan the page. And you can directly work when you are teaching in the class.

A teacher at school A said that the savings in preparation time are due to the avoidance of typing when making presentations.

> The hardest part in PowerPoint for me is typing. Typing is boring for me, too.

At school B, the science teacher said,

> I like the idea of scanning diagrams I make on paper. It would take me ages to draw these drawings in PowerPoint.

The efficiency gains achieved by scanning paper materials are possible when using PowerPoint as well, but in a preliminary examination, we found that teachers prefer to do this activity with Collage. Three out of the six teachers in our sample taught 2 different classes on the same topic, but they utilized Collage in one class and PowerPoint in the other. Scanned materials were used by them in both. All 3 teachers stated that displaying scanned paper content was

preferable in Collage because of the greater real-time interaction capabilities built into that tool.

Suitability for display of visual materials

Another perception which was consistently reported (and not just by teachers, but also by *students*) was that Collage is better suited than PowerPoint to display images and videos during classroom instruction. Again, teachers explained this based on the fact that the tool has more facilities to interact with content in real time,

> In Collage you have rectangle selection and whiteboard and we can write with the pen [stylus] in the whiteboard. In PowerPoint, [this is] not possible.

One teacher at school B commented,

> Overlaying images [on other images] is a good option. It is not there in PowerPoint.

Another said,

> What is interesting to me is that I can do activities around the pictures in class, whereas in PowerPoint one just shows the pictures and talks.

Interestingly, students feel the same way about Collage, too. We conducted a within-subjects study in school A to compare students' attitudes towards Collage in relation to PowerPoint. Forty-four tenth-grade students were selected as study participants and treated to two sets of classes – one taught using Collage and the other taught using PowerPoint. (All students had sufficient familiarity with both the tools, and had witnessed classes using each at least 10 times.) Two classes – one in science, one in literature – were taught using each tool, making it a total of 4 classes. The content and instructor for both the science classes were held constant[9] (only the presentation tool used for instruction differed) and similarly, for both the literature classes. To cancel the effect of order of treatment, we did some obvious counter-balancing: PowerPoint first, Collage second for science; Collage first, PowerPoint second for literature.[10]

When asked to identify the class in which they comprehended *only the visual content* (pictures) better, students voted strongly in favor of Collage, independent of the order of classes: 59% students in science, and 66% in literature. (Corresponding figures for PowerPoint were 36% and 31%; the remaining students were neutral.) Students could not articulate the reasons for their preference clearly, although some stated that in the Collage-driven classes, the

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[9] There were some minor presentational differences e.g., for the science class taught using Collage, the teacher used digital scans of handwritten notes, whereas for the one taught using PowerPoint, the teacher authored digital slides with the same textual content.

[10] Due to greater possibilities for interaction with content in Collage, the Collage-driven classes in our study lasted longer than the PowerPoint-driven ones. The science (resp. literature) class ran for 24 (resp. 15) minutes when the teacher used Collage, whereas it ran for 21 (resp. 11) minutes when the teacher used PowerPoint.

presentation of pictures "along with the teacher's notes" was "nice", perhaps suggesting that the intermingling of visual content with scanned textual content was appealing.

Downsides of Collage

One issue with Collage that some teachers reported was that it requires the teacher to regularly interact with the computer (via the mouse or stylus) during presentations, thus restricting her movement in the classroom. Although this criticism applies equally well to PowerPoint, the problem is more pronounced in the case of Collage because of its greater facility for interactivity. Furthermore, certain operations (like moving from a slide to its succeeding slide) are easier to conduct in PowerPoint and could potentially be carried out using a wireless mouse or a remote control only. In the case of Collage, however, the teacher must use a flat surface to interact with the application, or else resort to using expensive hardware like a Tablet PC or an interactive whiteboard.

The increased ease and efficiency of preparing content in Collage comes with some compromise in presentational quality. For example, scanned hand-written notes may not always be as presentable as well-formatted text in a PowerPoint slide and editing them may be difficult. The computer lab teacher at school B pointed out this trade-off during her interview,

> It may be easier to make presentations by scanning hand-written notes but typing gives you better quality. The text can be edited, too. If I have time, I will type.

CONCLUSION AND FUTURE WORK

In this work, we presented Collage – a presentation tool that is custom-made for instructional support in the K-12 classroom. The tool has undergone an iterative prototyping process, and the needs and limitations of the target users have influenced its design in several ways. We have deployed Collage in three schools in rural and semi-urban India and the feedback from our deployments suggests that the tool has some distinct advantages over PowerPoint, which is the most commonly used software presentation tool in schools today.

The field research and deployment of Collage has been conducted in fairly under-developed parts of the world (to be precise, rural and sub-urban India) which has influenced our design decisions and research outcomes in several ways. Yet, we believe that the lessons we have learnt in the field and the conclusions we have arrived at are applicable in more developed contexts as well. In particular, our findings are potentially applicable to teachers across the world who have limited computer proficiency and who have greater proclivity for using paper-based tools.

Our deployment of Collage in schools is still in a preliminary stage and while the initial signs are quite positive, there is the possibility of the "novelty effect" having influenced some of our findings. Whether or not the optimism around Collage and its high utilization can be

sustained at the rate that we have observed in our pilot schools, still remains to be tested.

Our evaluation of Collage vis-à-vis PowerPoint is also preliminary in nature. In particular, it will be useful to quantitatively evaluate the efficiency improvements Collage seems to offer over PowerPoint and whether or not the increase in interactivity during presentation slows down the progress of the class (and to what extent). It is also worthwhile to investigate simple and cost-effective ways to integrate student feedback into Collage. Finally, the role Collage plays in improving students' learning of curricular materials is still unclear and a careful investigation around this question is necessary before we scale up deployment of the tool beyond the pilot.

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