Textbooks for the 21st Century

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Despite important efforts to digitize already existing books and a good number of websites and CD-ROMs with educational digital content, we have only found a surprisingly small number of textbooks designed to take full advantage of emerging technologies, particularly for K-12. This is due in part to the fact that many efforts to bring technology into the classroom have concentrated in already resource-rich schools and looked at digital content as a complement, rather than a substitute of printed textbooks. With the advances in telecommunications and a multitude of devices for accessing digital content becoming more affordable and widely available, particularly in developing countries, we believe there will soon be a new market for digital textbooks that can replace printed ones and software to make use of them. It is also due to the paradigm transition that we are rapidly going through with education premises being challenged by global changes fueled by new technologies. Several initiatives have focused on replicating old textbooks on the screen rather than designing for this new medium. Some have created impressive materials for what seems to be the latest trend only to find out a little later that it does not run in the next version of software or hardware. We envision web-like digital artifacts that act as interactive multimedia textbook and collaborative notebook at once presented in a self-contained library that is easy to update. This builds on work done by Maciej in 2004 for the EduVision[1] E-Learning System designing a textbook reader interface for PDAs that receive content via satellite radio.[2]

[1] http://www.eduvision.or.ke/home/home.html
[2] Sudra, M. Teaching/Enhancing Education Through New and Emerging Media

Current Directions

In the past few years several major projects have been launched to digitize books and educational materials and make them widely available. Notable examples include Google Books Library Project[3], Project Gutenberg[4], MIT Open Courseware[5], the International Children's Digital Library[6], and Wikibooks[7] with more on their way like the recently launched Encyclopedia of Life[8]. An example of a localized effort at the country level is Mexico's Enciclomedia[9]. There are also atlases and maps, simulations, and other collections that tend to cover a specific domain like Google Earth[10], the Online Digital Microscope[11], Logowiki[12], and the Molecular Rover[13]. The question is what is the best way to present this vast amount of information and resources in a way that is useful for kids everywhere learning in the 21st century classroom.

While ebook readers for texts that already exist will play a key role to distribute valuable content originally created for print, devices such as PDAs, cell phones, iPods and laptops open new possibilities that would only be taken full advantage of by designing with them in mind. Wikis are one possible approach, but collective generation of knowledge in a system where everyone edits everything is not the only solution. Besides not being the most appropriate pedagogical tool in all cases, wikis are highly dependent on constant connectivity, which is unlikely in many school settings. The alternative of synchronizing changes adds a level of complexity that may make it impractical. At the opposite extreme of wikis, Enciclomedia is built to work with no connectivity, stored in DVDs, and put together by a group of experts. It places the classroom at the center of the process and puts the teacher in control of the technology. We think there is room for a third option[14].

[3] http://books.google.com/googlebooks/library.html
[4] http://www.gutenberg.org/
[5] http://ocw.mit.edu/
[6] http://www.childrenslibrary.org/
[7] http://en.wikibooks.org/wiki/Main_Page
[8] http://www.eol.org/home.html
[9] http://www.enciclomedia.edu.mx/Enciclomedia_english_video.htm
[10] http://earth.google.com/
[11] http://www.open2.net/science/microscope/frames.html
[12] http://www.logowiki.net/
[13] http://rover.concord.org/about/
[14] http://www.maciejsudra.com/OLPC/t561/textbook_comparison.pdf

Designing a new kind of textbook[15]

Carefully selected and organized curated content will continue to be important in the school system but it needs to be aligned with the new paradigms allowing for collaboration in the interconnected world. A textbook reader aimed at learners that allows for a combination of text and rich dynamic media while offering tools for generating your own content, can provide a good transition from the current curricula to more innovative, up-to-date pedagogy.

The audience for the textbook was at the heart of our design. Thinking about kids of all ages, around the world, learning in environments surrounded by technology, and preparing for a global economy made us considered hardware and software issues, connectivity, content, and pedagogy. Each of them influenced the design decisions made along the way to create a prototype[16] of our vision for textbooks in the 21st century.

- **Hardware**

Contrary to some science fiction representations, the 21st century classroom does not need to be a laboratory in a metropolitan area full of electric devices plugged into the walls. In fact, wireless and mobile technologies allow for almost any place to become a sophisticated classroom indoors or outdoors, with or without electricity and walls. With satellite radio and low cost, solar-powered Wi-Fi networks[17], cell phones, PDAs and laptops that are becoming more affordable will be able to connect to the rest of the world from virtually any location. This has several implications that impacted our design:

  - Size varies from the small screens, keyboards and buttons of the PDAs, to the medium XO and Classmate PC laptops, to regular size desktops and laptops, and even large projections on the wall. To address this -and other issues discussed in the appropriate sections below- our design favors unit subdivisions over traditional pages and works with adjustable font size. The “page” becomes what fits on the screen at the needed text size for a

[15] http://www.maciejsudra.com/OLPC/t561/large_poster.pdf
[16] http://www.maciejsudra.com/OLPC/t561/olpc_proto.html
[17] http://www.green-wifi.org/projects/gw/concept.html

given user and there are ways to easily navigate from page to page but also from unit to unit or between books. Images zoom in and out, just as the text, so the user can display enough detail regardless of the size of the screen. Software buttons are large and with enough separation between them to facilitate clicking with the mouse or the use of a touch screen when available yet they use as little real estate as possible to let the textbook fill most of the screen. Unlike other book readers that embed the images in the text making them very inefficient for small screens[18], we offer two solutions to display media: the original EduVision design for PDAs that places media in a separate tab[19] and an alternative that has the media, questions and annotations inline with the text but with the option to collapse or expand at will[20].

- Some computers like the OLPC XO and tablet PCs allow the user to rotate the content for vertical display. We decided to create an interface that works well when stretched favoring consistency and minimizing user disorientation. This is an area that would benefit from user feedback as it is feasible to take better advantage of this feature.
- While in tablet mode there is limited or no access to the keyboard. Our design is such that it is possible to easily navigate using the hardware buttons available when the laptop is "closed". Specifically for the XO, the arrow buttons scroll up and down and move to the previous or next item while the four controller buttons are used to choose between text, media, questions and notes.
- One of the features of the XO is that the screen automatically turns monochrome, sunlight readable, which is essential as in many parts of the world kids read outdoors. For this reason we made the interface for the XO in grayscale.

[18] Sudra, M. Development Powered By Education: How Much Information Can You Hold in One Hand?

[19] Sudra, M. Teaching/Enhancing Education Through New and Emerging Media p.22
[20] http://www.maciejsudra.com/OLPC/t561/two_versions.pdf

- **Software**

It is clear by now that the World Wide Web has taken off and will be around for a while. In just a decade we went from skepticism about its impact to global widespread adoption of it. If floppy disks opened the doors for authoring and sharing and CD-ROMs for cheap distribution of larger amounts of information they lack the strengths of the internet that will let the latter but not the former prevail in the current century with interconnections being at the top of the list. The innumerable advantages of being able to interconnect knowledge will ensure that standards are enforced and previous postings continue to be accessible.

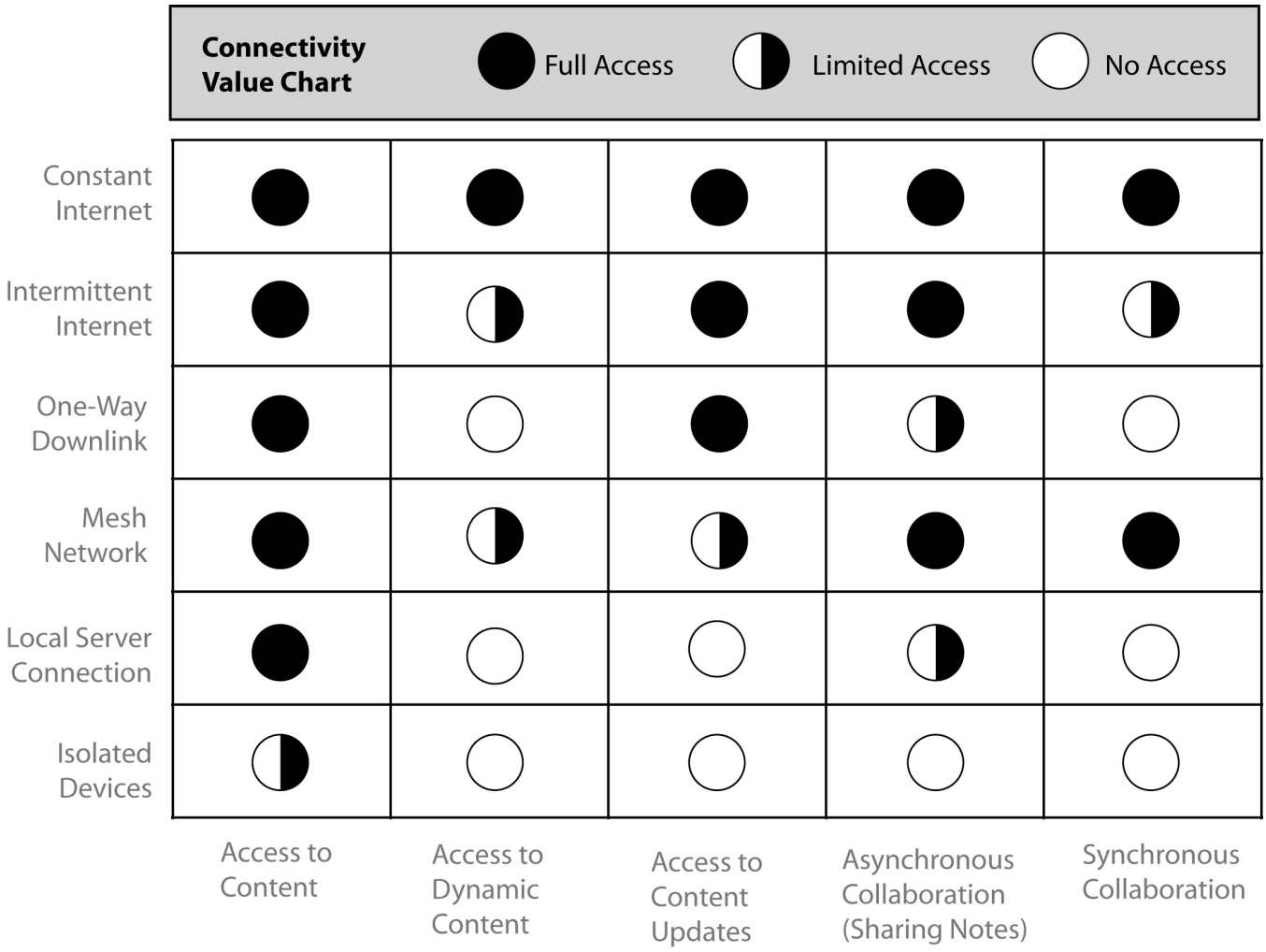
For the textbooks to reach the maximum number of children they have to run in multiple platforms and have minimal requirements in terms of processor speed, memory and the like. We have designed lean software that works with light scalable vector graphics, free of unnecessary effects, compatible with open source as well as commercial operating systems, that should load quickly even with slow connections. If needed the text can be loaded without media.

- **Connectivity**

The textbook reader was designed to work efficiently with or without connectivity. In the ideal user scenario students as well as teachers have access to a reliable Internet connection. However, this is not the case in many cases. Following are several connectivity models for the textbook reader.

  - Two-way constant Internet: Users can connect to the Internet whenever and wherever they choose to. They can receive and send out as much content as they wish. Under this scenario students as well as teachers would have access to the latest content and would be able to collaborate synchronously (e.g. read a book that only one of them has) and asynchronously (e.g. share notes).
  - Two-way intermittent Internet: Users can receive and send out content during selected periods of connectivity.

- Local Mesh Network: Users are not connected to the Internet but can send and receive content between other users within a certain distance that are connected to the mesh.
- One-way Intermittent: Users can receive content from the Internet but cannot send anything out. An example would be satellite radio that sends content to a local server or directly to the students, at set intervals.
- Local network: Users can connect to a server and access whatever information is stored there but have no way to access content from other users or from the internet.
- Isolated devices: Computers on their own, not connected to the Internet, any local network, or server.



Even without the extra benefits provided by access to other computers like quick updating and sharing, it is still very helpful to have an organized collection of textbooks with all the features that the stand-alone version has (search, annotations, highlighting, scroll-trail, etc.). As Joshua Schachter, creator of del.icio.us puts it: "If you need scale in order to create value, it's hard to get scale, because there's little incentive for the first people to use the product. Ideally, the system should be useful for user number one."[21] The textbook reader provides value for each and every user and for the educational system as a whole because it is cheaper than printed textbooks, it has rich media content that enhances the learning and it can be updated with little extra cost or supplies. Our design works in all cases even if some features are contingent on network access.

- **Pedagogy for 21st century paradigms**

Education has been based on the premise that information is scarce and individuals need to acquire it. Thanks to current information technology this premise no longer holds true; information is widely available and the challenge is to collectively make sense of it, navigate, search, sort, filter, connect, analyze, and generate, to ultimately be able to apply the knowledge in a way that positively impacts our quality of life. Educational systems have also been organized on the premise that knowledge is held by a few and has to be distributed in a top-down fashion with distinct sets of knowledge producers and knowledge recipients. In an interconnected world where many previously lost voices can suddenly be heard, it is becoming clear that knowledge is distributed everywhere and it is constantly recreated with the contributions of many diverse perspectives. Finally, for centuries the main medium for the transmission of academic content has been text. While we suspect that text will continue to prevail as an important component, other types of media are gaining importance providing new ways to process and understand information, and giving access to a wider range of audiences somewhat independently of their textual literacy. From ancient but undervalued oral tradition to emerging media like interactive videos, 21st century textbooks ought to incorporate a

[21] http://www.technologyreview.com/tr35/Profile.aspx?TRID=432

variety of rich and dynamic media. With these paradigm shifts in mind, we devised an interface bound to promote not only knowledge acquisition but also knowledge generation and sharing, using a variety of media, with appropriate knowledge management tools to manipulate the textbook content.

At the center of our design are the learners who we believe strongly should be in charge of their own learning process and tools. Our main audience is kids as young as 5 years old, but we created an interface that is appealing to older kids and adult learners as well. We assume that the initial users may not necessarily be technologically savvy but the textbook reader should help them to become fluent with technology and continue to serve them after they are acquire this fluency. Our motto is simple ways to do complex things. Our goal is to create an easy to use, intuitive, friendly, self-revealing interface that nonetheless allows for interesting behaviors such as non-linear navigation, collective authoring, personal cataloging and streaming of dynamic media. Below are some examples of these concepts in practice.

- As important as it is to become familiar with what the new paradigms afford and to learn from early on how to navigate the sea of information, it is to acknowledge that the large quantity of data available and the complexity of some of it can be overwhelming both for students and teachers. In order for them to have a manageable amount of resources while participating of what is available, there needs to be people curating the ever evolving body of knowledge and supporting the broad participation in the generation and sharing of knowledge. To address this our design leaves all the doors open so there is a constant flux of information in and out but preserving the sense of a circumscribed body of data. Books are created and updated by experts and delivered to the users organized by subject. They might include built-in access to streaming media, like satellite maps or visualizations of database collections, that are dynamically loaded on request when the user has the appropriate connection. They may also provide ways to utilize computer accessories like a camera to input photographs, sensors for capturing environmental data, or microphone for recording notes. User generated

content is added inside the books, linked to a fragment of the text, displayed in conjunction with the text that provoked them and with the authors and date of entry clearly identified.

- The digital textbooks are intended for kids all over the world who speak different languages, come from diverse cultures and live in a myriad of contexts. We expect the books that they will use to be as varied as their readers. Our solution is to let the textbook own the screen, comprise the navigation and tools in the minimum required space making them as unobtrusive as possible and create icons that evoke their function for most people.
- Given that the textbooks will be used in the classroom and after school, they are optimized for school tasks. Each book may have questions added along the way and they can be accessed within the text or through separate navigation. Each question has a textbox where the user can enter the answer and they could be shared with the teachers if desired. In a shared activity in the XO the teacher could highlight the text for everyone to see in their own book. A teacher could also share comments with a group of students.
- The textbook follows the applicable guidelines on universal accessibility: Adjustable font size, keyboard navigation and screen reader compatibility. In addition, everything works with a single click. To be implemented in the near future is a marker that highlights the line that is being read.
- A user is able to navigate through the textbook content in various ways. The choice as to the mode of navigation depends on a user's personal preference; however, depending on the material being viewed certain modes are optimal. A drop down menu lets the user choose what type of content s/he wants to navigate. Selecting text lets the user navigate through the textbook in a traditional linear manner with the left and right arrows changing screens as if a user were flipping pages in a paper textbook. Selecting media in the menu lets the user navigate through all the audio-visuals (images, sounds, videos, simulations, etc.) contained in

the open textbook, using the left and right arrows to jump to the previous or next image. Selecting questions lets the user navigate through all the questions in the book, left right arrows jumping between them. Lastly, selecting notes lets the user navigate though all the annotations s/he or any other collaborator has added to the textbook.

In addition, the user has the choice to expand all the non-textual content or have it appear as small icons within the text. If the user chooses the icon representation, clicking on an image, question or annotation icon opens up the corresponding content type. If the “Expand All “ button is pressed the content that gets expanded depends on the navigation mode the user has selected. Within the text mode all non-textual media gets expanded and the textbook functions not unlike its printed counterpart. Within the other modes (media, questions, notes) only the selected content gets expanded. So for example if the users wanted to quiz themselves on textbook content they might choose question mode through the drop-down menu, then press expand all, and then flip through the questions using the left and right arrows (“flash card” concept).

Finally, the user also has the choice to search the textbook content by inputting text into a search box. When text is entered in the search box the left and right arrows navigate through any matching occurrence of the entered text within the book. All the matching words are highlighted. The content being searched depends on what content mode has been selected via the drop-down menu.

- **Content**

"Educationally I think the number one question is when we look into the future and we see the computer as a medium for learning (...) do we think of the computer as improving how people learn the same curriculum or do we say this is an opportunity to put in question what people learn. How and What is the big question: I think it's What that matters." Seymour Papert on eContent.

Though we believe how we learn with computers is important, it is true that it sometimes overshadows the crucial issue of content. We would not be surprised if it turned out that the main reason why some educational technology initiatives fail has more to do with the content rather than with the technology, yet it is a common tendency to use new technologies to replicate old obsolete content. As much as we are advocates and believers of the benefits of using technology in education, we would choose good content with no technology over poor content with bells and whistles any day. Here are some ways that illustrate the interrelationship between intended content and textbook reader design:

- Getting the buy in of the education establishment, be it teachers, parents or governments, might be easier if there is a gradual shift from the traditional to the new curriculum maintaining as much of the familiar as possible without compromising the innovation. Our reader is designed to host up-to-date, innovative, rich media content but it is purposely conceived as a transitional medium that conserves many traits of the traditional school to facilitate the curriculum shift and avoid unnecessary resistance that might impede widespread adoption. For example, it is easy to transfer traditional textbooks to the digital format, improving the navigation and adding useful tools while maintaining the look and feel of the original book. It is equally easy to enhance it with additional multimedia content either added by experts as part of the digitization or by users through the annotation feature. This all provides for a gradual transition of content that might be easier to accept than other innovations like wikibooks.
- A balanced curriculum will mix universal ideas and concepts with content more relevant to local surroundings. For example students living on the shores of Lake Victoria may study the diverse fish population that neighbors them, while students in arid regions might learn about animal life in the desert. Instead of using different texts, they could start with a common basic biology textbook that is enriched along the way with their findings. Using the sharing functionality of our reader, they could then exchange their

contributions augmenting the textbook for both groups. They could also connect with global repositories to upload their findings and make them available for everyone who is interested.

- Keeping up with changes the in curriculum becomes a simpler process when dealing with digital data. In times when new scientific discoveries are made every day and history books are written from newspapers and blogs, updating a master and being able to efficiently distribute it becomes invaluable.

To illustrate our vision, we chose for our prototype the innovative engineering curriculum, Engineering is Elementary, developed at the Museum of Science, Boston. Even though it was initially conceived for print, it seemed like an ideal candidate to demonstrate the potential of textbooks in the new century. To begin with engineering is a brand new subject in elementary school curriculum. The books themselves have been written following an iterative design: prototyping, testing, analyzing, and refining them based on feedback from users, a process that could have been more efficient if digital textbooks were in place. Heavily based on math, science and technology, engineering relies on abstract concepts easily exposed with computer visualizations and simulations that can help make it more graspable for people outside the field. It is also interdisciplinary and can greatly benefit from the ability to integrate materials from different subjects, something the digital textbooks are well suited to do. The prototype shows some features that are currently functional in EduVision PDAs and OLPC laptops and others that would require further research to be implemented.

Future Potential

In closing, we want to highlight a few of the endless possibilities opened by this emerging technology.

It is already possible to insert an application into a digital textbook that allows the user to interact with a webcam hooked to the computer (see demo). It seems plausible and very desirable to add a magnifying lens to the camera so it can act as a microscope. A lot of what happens today, and probably even more of what will happen in the future, in several industries and in scientific research occurs at a scale not visible

with the naked eye. Concepts that we take for granted are unimaginable for many who have not experimented with instruments that let them see the microscopic world. Giving access to a microscope to every kid will help them grapple ideas that will be commonplace when they grow up. In the case of the environmental engineering book, children could be encouraged to take water samples in their surroundings and look at them in the microscope from inside their textbook. They could then write about their findings in the same digital book.

At the MIT Media Lab, researchers are already thinking about accessories for the XO to measure pH and electric current. Other types of probes and sensors may soon be available converting science books into laboratories for exploration. On the other hand, separate research on augmented reality may be adopted to have the textbook gather data wirelessly from an intelligent environment. For example, a textbook reader on a PDA could receive data from a sculpture about its history or creator via RDF.

In addition to the mouse, the drawing pad, and the touchscreen, tangible and gestural interfaces will expand the palette for interaction with the books in ways we could only begin to imagine. Probably sooner we could see more audio commands reducing the need for a keyboard and making the experience more intimate, closer to what we have with printed books.

The future semantic web promises to bring exciting tools for collaboration, integration and connection of resources that would take the digital textbooks to the next level. We can’t wait!