On the Feasibility and Utility of Web based Educational Lesson Plans

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ABSTRACT

The Web has a wealth of educational information across different topics, which can potentially be used to improve teaching. In an attempt to harness this potential we developed a Contextual Information Portal(CIP) for education and deployed it in schools in Kenya and India. The portal crawls the Web and tries to collect documents for different subjects and creates a repository of relevant information. In this context two very basic question arise: *What is the quality of these online contents?* and *Can these educational web materials be effectively used to teach classes?* Answering the former question is fundamentally hard since there exists no standardized measure for the utility of web-based educational resources. This paper aims to answer these two questions in this larger realm. First, using 6 expert teachers, we study the *content quality problem* from a teacher's perspective of whether there exists sufficient information on the Web to teach classes pertaining to the school syllabus. To investigate the second question, we accepted the help of an expert teacher. Evaluations were based on her feedback after creating lesson plans using the CIP for grade 8 mathematics and taught several classes in an after-school program. We found that in general, the Web has sufficient number of high-quality contents and lesson plans obtained from the CIP are useful in teaching a class.

1. INTRODUCTION

Over the past few years, there has been a growth in the number of educational projects that have leveraged web-based resources [1, 7, 14, 34, 35, 3, 15, 16, 6] for enhancing education. Many schools in the U.S. are equipped with computer labs for course materials, topic specific information resources, or digital literacy courses. The Internet, and the Web in particular, are increasingly used in developing regions to enhance education.

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In our limited experiences as part of the Contextual Information Portals (CIP) project, we have deployed educational web-based portals in several schools in India and Kenya. The basic goal of the CIP project is to build a vertical slice of the Web that is relevant for the school syllabus and make this vertical slice locally available to teachers and students. CIPs are explicitly designed to provide a browseable, searchable and navigable web experience in offline environments with limited or no Internet connectivity. In order to achieve this objective, the design of CIPs uses a combination of focused crawling, classification and web indexing techniques. From the student or teacher perspective, the goal is to provide a web access experience for educational content relevant to the school syllabus. Despite all our deployments and use-case scenarios, one of the central questions that has remained unanswered in our work is to measure the effectiveness of the CIP platform as an educational tool for teachers and students.

In this paper, we analyze this problem from the perspective of teachers in the limited context of the CIP project. We specifically aim to answer two simple questions:

Content Quality: Can teachers find sufficient high quality information from the web that can be used for teaching classes?

Organization, Presentation: Suppose a teacher wants to teach a class on a specific topic, how can the teacher effectively use a CIP platform to find, organize and present web-based content?

By answering these two questions, we hope to understand whether CIPs could be useful for teachers to leverage web-based content to teach classes.

The original CIP design simply presented a search interface that allowed users to search for web content. To enhance the usability of the system for teachers, we built a simple bookmarking tool that allowed users to bookmark and organize relevant pages corresponding to a topic. The tools allows teachers to specify a "lesson plan" corresponding to a topic, where a lesson plan represents a simple flow of thought that captures the order the teacher wishes to teach a class. Corresponding to the various points in the lesson plan, the bookmarking tool allows the teacher to bookmark relevant pages and create a web-based lesson plan for the topic; the teacher can easily distribute lesson plans to other teachers and students.

In the first question, we study the feasibility of whether

teachers can find high quality content on the Web to construct meaningful lesson plans for different subjects. In the second question, we aim to study whether lesson plans represent a useful abstraction for organizing web-based material and teaching educational classes. To address the content quality question, we worked with a set of 6 expert teachers in India across different subjects, each with over 15 years of teaching experience. We chose one topic within the domain of expertise of the teacher and asked the teachers to rate the quality of web content for teaching classes across a range of metrics. To address the organization and presentation question, we worked with one expert teacher to perform a more in-depth study on a specific subject. Here, we considered a one-year syllabus for a subject (mathematics) for a specific grade (8th grade) and had the teacher manually construct lesson plans for all the topics within the syllabus. The teacher then used the lesson plans to teach classes in an after-school program.

Based on our user study, we make the following salient observations:

- There is sufficient amount of high quality educational content on the Web for all of the chosen topics.
- The Web enables exploratory learning for both students and teachers. Web-based resources for ideal for activity based learning, a new requirement in the Indian school syllabus, which enables students to perform several activity-oriented projects.
- Despite the large amount of educational content, finding the most relevant content for a particular class takes several hours.
- Filtering the appropriate content and organizing the content sequentially to correspond with the syllabus for a topic is not an easy task. Often, this requires a teacher to choose small parts of content from several sites and connect them together.
- Teachers find lesson plans a useful abstraction from the perspective of teaching classes. Classes tend to be more interactive and teachers are able to use a variety of online resources (images, videos, examples, slides, problems) to make teaching more fun. The Web also promotes new visual learning techniques and makes instruction potentially less burdensome for the teacher.
- It is easy for students to get lost while using web-based resources and students may need the aid of the teacher to view the appropriate content in the correct order for better understanding of the subject.

2. CIP: BACKGROUND

Contextual Information Portals represent a powerful and new paradigm for information access in regions without sufficient information sources and networking infrastructure. CIPs allow a different model of information access since they can be stored on any large storage media (e.g., hard disks, DVDs, USB Keys, or SD Cards), and shipped as a self-contained Web cache to any geographic location. CIPs are complementary to existing mechanical modes of bulk digital information dissemination which makes them easily deployable [33, 32, 3].

There are several specific areas where CIPs could be useful for different knowledge domains and scenarios, such as: Agriculture, Medicine, Education, and Location-specific Web portals.

2.1 Design

The basic premise behind Contextual Information Portals is that the context informs the specific information needs. In our case, the educational syllabus of a school could represent the list of topics of interest for students and teachers within a school and the CIP should be able to search the Web and find and collect all relevant documents around those topics. We divide designing a CIP into three high-level design constraints. First, the information stored in the cache should be context appropriate. Second, the solution should be efficient in terms of relevant pages downloaded; both crawl bandwidth and disk space are limited resources. Third, the final set of pages in the CIP should not only be searchable but also *browseable* in some fashion.

The approach we take is to use a focused Web crawler to crawl the Web for pages that are relevant to the specified topic. The crawl is initially bootstrapped using the search page results corresponding to a fixed set of queries about the specified topic to a search engine. Blindly crawling Web pages even when given a relevant starting point is problematic: pages a few links away are often irrelevant. Building a focused crawler requires us to use a good document classifier that accurately classifies pages relevant to a topic. Next, we describe our approach. Our system involves four steps:

Step 1: Defining topics. The topics were chosen following the syllabi of school curriculum as provided by the educational board.

Step 2: Training a classifier. The purpose of a document classifier is to determine whether a page is relevant to a specific topic. We designed and implemented a custom feature extractor that is compatible with several existing classifiers and provides high classification accuracy with minimal training.

Step 3: Focused Crawling. To perform the actual crawling process, we implemented a focused crawler based on the Shark crawler [31]. The goal of a *focused crawler* is to crawl only the relevant portion of the Web that relates to the topic while minimizing the waste of downloading unrelated pages.

Step 4: Presentation. While the crawler simply outputs a large number of Web pages, it is essential to organize these pages into a searchable and browseable repository. We use a combination of existing proxy cache implementations and search indexing implementations to construct a presentation layer which presents a simple search and URL interface usable from any standard browser.

Although our system is largely automated, the human is included in the loop to guide the automation. The topics are generated by people, sites that are irrelevant are blacklisted, and presentation blacklisting useless sites, and although we do not discuss it in detail, we use a simple bookmarking tool to assist instructors in building lesson plans from the pages. CIP implementation details may be found in our previous work [15].

2.2 Deployments

A CIP was initially deployed in an after school program in Kalapakkam, India. There we constructed a CIP for mathematics for 8th standard from an after school program in

Kalpakkam, India. The CIP was constructed using the titles of 17 chapters of grade 8 Mathematics curriculum of the Central Board of Secondary Education of India (e.g. "square roots", "volume and surface area", "introduction to statistics", etc.). The portal was configured to download 500 complete Web pages for each of the topics, and the set of pages downloaded was approximately 5GB in total (compressed). The total time for gathering the appropriate pages was approximately 8 hours on a single desktop machine in the U.S. with a 2Mbps connection.

We setup the portal on a computer that was already in the classroom. We then demonstrated the use of both the portal and a simple bookmarking tool for constructing lesson plans to the teacher. Software setup and training took roughly 30 minutes and 1 hour respectively. The lesson plans, experiments, and usage of the portal were designed, executed, and decided by the teacher herself without any direction from us. The teacher was given complete freedom on how to use the portal. She used the portal to teach the 8th standard material to her students who were in 6th and 7th standard. We observed her use of the portal over the course of one week, and at the end of the week we interviewed the teacher and gave the students questionnaires relating to their experiences.

After a preliminary testing in India, for our large-scale pilot we worked with a university in Nairobi that was already involved in weekend teaching activities at 5 schools near the city. The schools were all within 75 km of Nairobi, though the distance is slightly deceptive due to the poor quality of some roads. We were requested by the teachers at the university to construct a CIP for "computer studies" which is why much of our evaluation thus far has focused on that subject.

The university program involved $4-5$ undergraduate computer science students traveling to each school nearly every Saturdays during the school year and teaching students subjects in computer studies. We decided early on to leverage this existing program to bootstrap the use of the CIPs. The students and their program manager have agreed to use the CIP for the next several months as the primary teaching resource. The students themselves are qualified to teach, maintain, and upgrade the software for the CIP and resulting portals. The initial student and teacher responses at both the university and the schools have been extremely positive.[1]

3. LESSON PLAN CONSTRUCTION

In order to teach a subject in a class teachers need a structured organization of the topics and the materials, which is the *lesson plan*. On the other hand, the CIP tool was designed just to crawl the web and collect educational materials from the web and create a repository of contents. This set of contents are supposed to be scrutinized by the teachers and use them effectively to teach in classes. However, manually organizing the materials and creating lesson plans from a huge set of documents and using them to teach in classes can be difficult and time consuming. An additional layer on top of CIP was necessary to help the teachers organize the contents and efficiently create lesson plans.

[1]Deployment at School 3 has been delayed due to internal conflict between the instructor and the principal which is still in the process of being resolved.

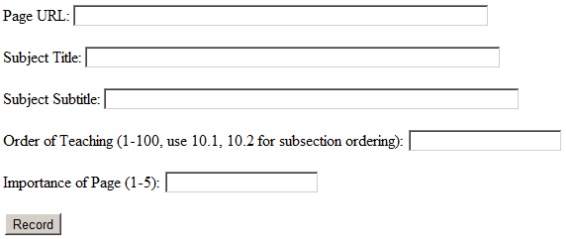

Figure 1: Screenshot of the bookmarking tool for lesson plan construction.

3.1 Bookmarking and Lesson Plans

We built a bookmarking tool as an extension to CIP system that can help teachers create lesson plans with reduced effort. As the teachers browse the materials, using browser for a particular subject, they can create a customized lesson plan by organizing Web contents. This feature in the system was implemented as an extension to the Firefox browser. Figure 1 is a screenshot of the simple bookmarking form interface. To teach a class on a given topic, a teacher first searches the offline portal to determine potentially relevant web pages which contain relevant content, examples and problems related to the topic. The teacher constructs a lesson plan using the bookmarking extension while she browses. The bookmarking extension has the functionality for starting a lesson plan, bookmarking pages along with annotations for the pages, and editing/removing the bookmarks, and exporting the lesson plan. An exported lesson plan is in the form of a web page of hyperlinks organized as per the teacher's specification.

The bookmarking tool could also allow the most competent teachers to share lesson plans easily by copying lesson plans across portable media (e.g. flash drives). The bookmarking mechanism also allows teachers to easily guide students' use of the technology without being seated at the computer herself. Children at young ages have been observed to have various problems with the ergonomics and concepts involved in search causing them to become easily distracted and discouraged [4]. Our system, and particularly the bookmarking tool can be a stepping stone for children by avoiding these search-specific issues.

4. EVALUATION METHODOLOGY

In this paper, we are trying to answer two questions. In this section, we state the questions, briefly explain the methodology to evaluate the questions.

Can expert teachers find sufficient high-quality information on the Web that can be used to teach classes?

Can the web contents be effectively organized and used to teach in classes?

The detailed studies are discussed in the following two sections.

5. CONTENT QUALITY EVALUATION

Our first question is centered around the issue of quality of educational content on the Web pertaining to a topic of interest. To evaluate this question, we worked with expert teachers and asked them to assess the quality of Web content

relevant to specific chapters within the school syllabus. In this section, we describe our evaluation methodology and also describe the assessment from the expert teachers for each of the individual topics across subjects in detail.

5.1 Methodology

For this evaluation, we considered the Central Board of Secondary Education (CBSE) curriculum in India. We chose 6 different topics across five broad subjects. The topics varied between 8th and 12th grade in the CBSE syllabus as we wanted to have a high diversity in the topics chosen. We primarily focused on early high school since we believe that represents an important age group in school, where students have the maturity to navigate educational content on the Web and explore beyond the confines of a fixed syllabus. The subjects and the topics are enlisted below.

- Mathematics: Linear equations: 9th grade
- Physics: Pressure: 8th grade
- Science and Social Science: Crop production and Management: 8th grade
- Biology: Microorganisms: 9th grade
- Commerce: Scientific management: 12th grade

Except for the crop management topic, we picked exactly one topic for all the other subjects. While Crop production is primarily taught in Science, we also found repeated reference to crop production in the context of social science subjects. Hence, we obtained a dual perspective from two different expert teachers on this topic. For each topic, we took the table of contents for that particular chapter in the standard Central Board of Secondary Education (CBSE), India approved textbook. Based on the table of contents of those books, we gathered a list of sub-topics for each topic. Using these sub-topics and the topic name, we issued several queries to a search engine (one query for each subtopic along with the topic name) and downloaded the top search results for each query. All these search results were pre-filtered to a reduced corpus of $50 - 100$ sites for each topic. After obtaining these set of documents, we recruited an expert teacher from the area of the topic to evaluate the content across a variety of metrics. The expert teacher then gave her comments on those documents based on her expertise and experience. The experts were also given the option of choosing alternative materials in case they did not find anything appropriate within the given set. All the expert teachers have several years of teaching experience in premiere schools and colleges in India. We next outline the expert teacher's feedback for each of the individual topics.

5.2 Mathematics: Linear Equations

This topic was chosen by the expert teacher and the rationale provided by the teacher was as follows:

"Generally in mathematics textbooks, graphs (not to be mistaken with graph theory) and linear equations are taught separately. Graphs come under coordinate geometry and linear equations come under algebra. Despite the strong interlinking between these two concepts, most school students are unable to visualize the association between them. To associate the intersection of 2 lines as the solution point of solving 2 linear equations was something most students could not comprehend." The teacher felt that with the web materials, one can explain this relationship easily with several examples and figures; something, that is not often present in textbooks. Some sample websites the expert teachers used and rated for linear equations include,

- http://www.studygs.net/equations.htm (4)
- http://www.purplemath.com/.../solvelin.htm (4)
- http://www.youtube.com/...?v=CEVvH9uX6QA (5)
- http://www.purplemath.com/.../solvelin.htm (3)
- http://www.eduplace.com/math/.../index.html (5)

The values in the parentheses depict the rates the expert teachers gave to the sites on a scale of 5, where 1 represents poor and 5 represents excellent. In general, the teacher found several websites that provided useful content for the topic. The teacher felt that given readily available web-based resources teachers need not spend much time on references from the library to prepare for a topic. The teacher felt that the content of the syllabus is very well covered and the introduction to the topic is particularly noteworthy. Wikipedia provides a wide range of ideas about this concept and small doubts can be clarified using this as a source. However, she noted that one fundamental problem with Wikipedia is that the level of difficulty quickly shoots up beyond the 9th grade level and most of the content is more relevant for 11th grade level. In general, finding the most appropriate content for a specific class seems a hard task to manually shift through several pages.

Table 1 provides detailed feedback from the teacher about the utility of the content across a variety of metrics. Some comments from the teacher were:

"The graphical representation gives a clear idea about intersecting lines and parallel lines. The teacher is able to interlink the slope of the line and the coefficient of the variables. Different forms of equation are to the level of 11th grade and sometimes inappropriate to lower grades. Good information is available if we search carefully and the content is certainly useful to explain to the students properly. Teachers guidance is very important to understand their level of requirements. There are sites with solved problems and with assignments and the teacher need not strain to prepare the assignments. There are lot of practical examples which will kindle the interest in the child to think beyond. The power-points are often self explanatory. From these websites, many activities and project works can be given. There are few web sites which exactly pertain to the board and curriculum and these can be valuable and appropriate for the understanding level of the students also. It gives a wide knowledge of practical usage and explains the situations where these types of problems occur. There are few paid web sites which has lot of solved problems and assignments. Overall, this was an enjoyable experience."

5.3 Physics: Pressure

Pressure is a classic example of a physics topic that introduces a new concept in Physics to high school students. At the 8th grade level, the textbook syllabus covered the basic concepts of pressure and related these concepts in real-world settings such as water pressure, atmospheric pressure

Table 1: Content Rating for Linear equations

Type of content	Rating	Comments
Definition	Very good	Well defined, good introduction
Basic concepts	Very good	Well covered and clear
Advanced concepts	excellent	Co-relation with graphs inconsistent
Real-life examples	Just sufficient	Sufficient for class room teaching
Applications	Very good	Good teaching aid, saves time, can reinforce, recollect, recall
Problems	Sufficient	Text books can be used for extra assignment
Real-life problems	Only few	Question banks in paid sites
Textual content	Highlight relevant lines	Too much information. Makes explaining hard
Video	Very good	Makes explanation clear and crisp
Pictures	Graphs are good	Makes it easier to understand
PowerPoint	Very good	Good resource
Activities	Several	Lots of problems on 2 variables

and pressure of gases. The concept of "Force" had been covered prior to this chapter and it is assumed that students are aware of "Force" related concepts. However, the book does not go into details on different hard problems related to pressure.

Sample introductory websites chosen by the expert teacher include:

1. hyperphysics.phy-astr.gsu.edu/hbase/press.html
2. en.wikipedia.org/wiki/Pressure.
3. kids.earth.nasa.gov/archive/air_pressure/

And some slightly more advanced sites included:

1. www.physicalgeography.net/fundamentals/7d.html.
2. www.elmhurst.edu/.../vchembook/180pressure.html.
3. www.kentchemistry.com/.../GasLaws/manBar.htm
4. www.excellup.com/ClassEight/.../forcepressure.aspx
5. adawe.wordpress.com/.../science-8-forces-pressure

The overall feedback from the expert teacher are summarized in Table 2. Several aspects are noteworthy. First, while content is available, not all content is appropriate at the particular class level. Often, the content covered in web sites very soon go beyond the basic understanding of the students. Second, finding appropriate sites does consume reasonable amount of time for each sub-topic. This is specifically true for PowerPoint, videos and appropriate images. Third, the content is often scattered across several sites that assimilating them together sequentially to match with the syllabus can be a challenging task. Finally, lot of sites have good pictures and videos but the associated explanations need to be tailored for the particular class setting which requires the aid of the teacher.

5.4 Crop Production

For crop production, we analyzed the topic from both a science and a social science perspective. This was a suggestion that was proposed by the expert teachers themselves. While crop production is primarily covered in the science subject, it is also covered repeatedly in social science in the context of world history. Another reason teachers felt this topic was interesting was that it was very closely tied to reality and allows exploration in a variety of dimensions.

Tables 3 and 4 provide the key observations from the expert teachers on crop production from both a social science and a science perspective. The science teacher's opinions from this experience are summarized below:

"E-learning is advantageous when used properly as the links provide lots of information related to a single topic. For certain subjects like science, students can get exposure to latest technologies that are not much updated in the syllabus. To learn beyond the textbook is of utmost importance for present day students and this must be made compulsory for the teachers and students. Video clips and images related to the topic can help in proper understanding of various concepts. Visualized learning makes students remember the concepts well."

Same of the salient opinions from the social science teacher for this subject include:

"Content is very extensive and detailed and requires a lot of guidance from the teacher to edit and navigate for the student to figure out what is appropriate. Students can apply the knowledge for comparative studies, projects and conduct debates. The content promotes exploratory learning and the content is not abstract but is understandable in most cases that 8th grade students can handle. But how much they can really understand depends on how good the teacher conveys the material. Teachers can edit, sum up and create different manuals and questions."

5.5 Biology: Micro-organisms

In Biology, we picked the topic of micro-organisms covered at the 9th grade level. The feedback from the teacher was largely positive. "Excellent" or "very good" ratings were given for all headings except classification and sub-topics due to poor or irrelevant content. The expert teacher made several important observations. First, web sites provide better definitions when compared to textual information and help in better understating of the basic concepts of microbiology. Second, websites are very helpful in making students learn how the field developed. Third, parts of the textual content is stale in this fast-moving field that there has been a recent update in the Classification of microorganisms not described in textbooks.

In general, the teacher found that there was reasonable detail on the sub-topics for each type of microorganism includ-

Table 2: Content Rating for Pressure

Type of content	Rating	Comments
Definition	Good	
Basic concepts	Very good	Several good sites
Advanced concepts	Good	Many sites are too high level for 8th grade
Real-life examples	Good	Several examples online
Applications	Very good	Several examples
Problems	Sufficient	Some sites have appropriate problems
Textual content	Good for basics	Sometimes too high level
Video	Very good	Some Youtube videos are apt (specially for water pressure)
Pictures	Good	Pictures exist but explanations not always clear
Powerpoint	Very good	PPTs have better examples
Activities	Some sites	Activity sites need better pictures

Table 3: Comments on based on materials of crop production from science perspective

Heading	Rating	Comments
Definitions	Very good	Good information including origin of crops
Basic concepts	Very good	More details outside of syllabus
Advanced Concepts	Excellent	Good for Assignment projects
Real life examples	Very good	Several real life examples
Applications	Excellent	Makes it appear real. Captivating
Problems	Not relevant	Opportunities for projects

Table 4: Comments on crop production from social science perspective

Heading	Utility	Comments
Text	good teaching aid	Well explained, enrich the knowledge
videos	Excellent	Doubts are also clarified
PPTs	Good	Relevant to the school level
images	Excellent	Highly informative
activity	numerous	Several real-world activities

ing real life examples that cover the beneficial effects of microorganisms and health related issues, and precautions and treatments. Content about different industrial and health care related products from microorganisms were also found. In particular, the illustrations and animated videos enables learning and understanding a topic in an easy manner. Microbiology is a very visual subject, where appreciating the concepts of how life functions is easily benefited by different kinds of images and videos present online. Our teacher found that web sites helped inspire students to learn more about a topic by providing interesting links with challenging puzzles.

5.6 Commerce - Scientific Management

As a comparison, we considered the topic of "Scientific Management", an important chapter in the curriculum of Business studies for 12th grade classes for students specializing in Commerce. We summarize the key observations made by the expert teacher for this subject.

1. From a content perspective, the textbook covers only one or two definitions while several different definitions are online. This can be both good for broader understanding but also highly confusing from an exam perspective.

2. "Scientific Management" as a subject can be semantically a very confusing name. However, several sites have clearly articulated the meaning of this subject in a detailed manner with many practical examples.

3. The principles of scientific management are explained in an elaborative manner with appropriate illustrations and videos.

4. Given the volume of information, students can enrich their knowledge, higher order thinking skills and also do self-paced learning. The tools and techniques have been well explained. It is important for students not to get lost in the massive web of information.

5. There are also several case studies online which are applicable for this subject, something that is not common across other subjects.

5.7 Activity-based Learning

As part of our final section on content quality evaluation, we focus on the specific area of finding Web content for *activity-based learning*. Activity based learning is a recent mandate from CBSE. The board made it compulsory to allocate 20% of a subject score to practicals, which is learning based on experiments and activities. Currently, there exists no book within CBSE that explicitly mandates a well-defined set of activities for each subject. Hence, this represented a good way for testing the effectiveness of the utility of Web contents. We chose different topics in mathematics and science and asked the expert teachers to manually search the Web (using a search engine) and find relevant sites that contain specific activities or scientific experiments to explain specific concepts within each topic. The expert teachers marked a site as useful for a particular grade only if it contains one or more activities that can be easily executed and understood by students within a particular grade.

Evaluation and Feedback: We chose 15 topics in mathematics and science for this study. In mathematics, some of the topics include: geometric shapes, properties of triangles, angles, numbers in nature, Fibonacci series, triangular numbers, rational and irrational numbers. In science, some of the topics include: force, gravity, motion, levers, pulleys, static electricity, color of light, atmosphere, energy, atmosphere and gases. The main feedback we obtained from the expert teachers from this exercise was:

1. For each topic, they were able to identify several web sites (typically > 5) that describe specific activities to teach the concepts for students at a particular level.

2. The process of manually identifying relevant content for students of a particular level is sometimes an arduous task; finding content with the level of simplicity for lower-grade levels can be challenging. The overall effort across the 15 topics consumed more than 5 human-hours.

3. One of the powerful aspects of Web-based educational resources is that they contain several activities, problems and examples that go beyond the content covered in the text book syllabus. This also enables to tailor the educational content to each student appropriately.

4. Characterizing the right search queries for identifying relevant content for a particular level can be a challenging problem.

6. LESSON PLANS AND TEACHING CLASSES

The focus of this study was to use the portal in a real-world scenario and evaluate it through teacher usage and feedback from the teachers. To test the efficacy of the offline portal, it was deployed in real a classroom of an after school program in Kalpakkam, India. A snapshot of the classroom is shown in Figure 1.

6.1 Participants

The teacher is a 54 year old woman, who has been teaching children from 1st to 12th standard for 30 years. She teaches all subjects in the syllabus. She is fairly comfortable with computers, and average in her web competency.

Nine students, three of them girls, belonging to 6th and 7th grade (all around 11 years old) attended the classes. We chose students younger than the lessons to evaluate the portal by teaching students who had no prior knowledge on the topics being taught. Out of the students, only one was not familiar with computers. The rest of the students were average to familiar with computers and nearly all of those students used them for between 0 to 1 hours a day.

6.2 Procedure

The offline portal was constructed using the titles of 17 chapters of grade 8 Mathematics curriculum of the Central Board of Secondary Education of India (e.g. square roots, volume and surface area, introduction to statistics, etc.). The portal was configured to download 500 complete web pages for each of the topics, and the set of pages downloaded was approximately 5GB in total (compressed). The total time for gathering the appropriate pages was approximately 8 hours on a single desktop machine in the U.S. with a 2Mbps connection.

We setup the portal on a computer that was already in the classroom. We then demonstrated the use of both the

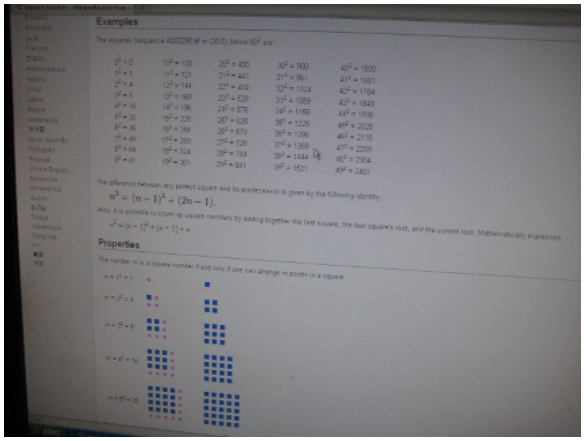

Figure 2: Screenshot of a Wikipedia content page on square numbers being used by a student to explain that sum of consecutive odd numbers starting with 1 form a square.

portal and bookmarking tool and trained the teacher to use them. Software setup and training took roughly 30 minutes and 1 hour respectively. The lesson plans, experiments, and usage of the portal were designed, executed, and decided by the teacher herself without any direction from us. The teacher was given complete freedom on how to use the portal. We observed her use of the portal over the course of one week, and at the end of the week we interviewed the teacher and gave the students questionnaires relating to their experiences.

6.3 Lesson Plan Construction

During this study, the teacher used the bookmarking tool extensively to create her own lesson plans for each of the 17 chapters in the 8th grade mathematics syllabus. The time for constructing a navigational path for a chapter varied between 30 minutes to 1 hour. Here, the teacher had prior knowledge about the subject and could quickly determine which sites were relevant for the topic. For a single navigational path, the teacher issued between 6-15 queries to the portal and browsed roughly 20-40 web pages before short listing a list of relevant pages for a navigational path. The average number of pages in her navigational paths were 6.

For certain topics a few web pages covered a large portion of the material while for certain chapters the teacher used up to 14 different web sites to teach the topic. In comparison, the textbook had less than 15 pages of boldface text per chapter; the web site content a larger volume of information overall. The teacher also found several examples and problems for the navigational paths. The most popular websites among those she used in her lesson plans include, *wikipedia.org, www.mathsisfun.com, www.mathwords.com, www.mathsteacher.com, www.onlinemathlearning.com.* A lesson plan constructed by the teacher for 2 chapters in class 8 Mathematics is shown in Table 5.

6.4 Results and Observations

The portal was used to teach some mathematical concepts related to 8th grade syllabus to a group of 9 students belonging to 6th and 7th grades. We specifically picked lower-grade class students since they had no knowledge about the topics. Topics such as quadrilaterals, polyhedrons, squares and square roots, Pythagoras's theorem etc. were taught during this class. Each class lasted for one hour followed by a half an hour session where the students experimented with the portal primarily with the pages within the navigational path. Despite having no prior knowledge of these topics, the students were quick to grasp the concepts; they were able to answer questions related to angles of these figures. The students were also more involved and participating during this class than usual.

During one of the classes, when the topic square of numbers was covered, the students were asked to use the portal by themselves and identify interesting patterns related to squares. The students had no problems interacting with the portal using the bookmarking tool, and after using the portal the students came up with interesting observations. Some observations made by the students were: they found that none of the whole square numbers end with 2, 3, 7, 8. One student found that the square of any number ending with 5 ends with 25. The student could also devise a shortcut method to find the square of numbers ending with 5, using the initial observation. Another interesting finding was, they discovered that the sum of first 'n' odd numbers is equal to the square of 'n'. A screenshot of the page related to square of numbers is shown in Figure 2. In this context, the students were briefly taught the relationship between squares of numbers and the Pythagorean theorem. They were also taught Euclid's formula for generating Pythagorean triplets. Using one taught example, the students were able to generate a lot of Pythagorean triplets. While teacher guidance was essential for initial direction, all these observations were made by the students themselves after browsing the relevant pages.

6.5 Teacher's Feedback

The teacher gave an elaborate qualitative analysis of her experience teaching the class with the tool as well as her opinion about the tool. The teacher felt that the bookmarking tool was useful because it reduced the time and effort for constructing teaching plans. Using this tool was as easy and intuitive as browsing the pages and she could create the plan simultaneously as she was going through the portal for useful pages. The teacher found the portal easy to use and navigate. She also added that she found it more useful than the web because it was easier for her to find appropriate materials through the portal than finding them in the web. Also, according to the teacher, various websites have paid services or free services only for a trial period and the contents accessible through this portal, although fewer compared to the web, are always available and easy to access.

The teacher did point out some limitations and caveats to the portal. She mentioned that the portal can be useful to teach concepts, but it may not be as good as for self-learning. She argued, particularly, students from higher grade need a teacher for guidance, particularly for problem solving. Her rationale was that different problems need different strategies, and not all can be learned from a tool like this one. She also observed that students who have some knowledge on the subject will enjoy greater benefits from this tool although some students without any prior knowledge managed to grasp the concepts well. She concluded that, minimally, for teachers the system was a helpful tool for education delivery.

Table 5: Lesson Plan for Mathematics, Class 8

Chapter: Rational Numbers	
Definition	http://en.wikipedia.org/wiki/Rational_number http://academic.sun.ac.za/mathed/malati/RatNumbr.pdf
Properties	http://www.mathsisfun.com/algebra/rational-numbers-operations.html
Square and square root	http://en.wikipedia.org/wiki/Square_root http://www.factmonster.com/ipka/A0875883.html http://www.purplemath.com/modules/radicals.htm
Cub and cube root	http://www.1729.com/blog/CubeRoots.html www.quickermaths.com/finding-cube-root-a-vedic-maths-way http://www.mathsisfun.com/numbers/cube-root.html http://www.ehow.com/video_4757595_factor-cubed-roots.htmlw.learnnext.com/class8/maths/Cubes-and-Cube-roots.htm
Factorisation	http://www.basic-mathematics.com/factoring-algebraic-expressions.html http://teachers.henrico.k12.va.us/math/hcpsalgebra2/Documents/5-4/factoring_poly.ppt
Chapter: Geometry	
Polygon	http://en.wikipedia.org/wiki/Polygon http://www.mathsisfun.com/geometry/polygons.html http://www.math.com/tables/geometry/polygons.htm
Quadrilateral	http://en.wikipedia.org/wiki/Quadrilateral http://www.mathsisfun.com/quadrilaterals.html
parallelogram	http://en.wikipedia.org/wiki/Parallelogram http://www.mathsteacher.com.au/year7/ch09_polygons/04_quad/quad.htm http://www.mathwarehouse.com/geometry/quadrilaterals/parallelograms/
Exterior angles	http://www.mathsisfun.com/geometry/exterior-angles-polygons.html http://en.wikipedia.org/wiki/Internal_and_external_angle
Paper folding	http://geogebracentral.blogspot.in/2011/04/paper-folding-and-proof.html

7. RELATED WORK

There have been numerous studies which have experimented with Web based educational resources [6, 7, 1, 3]. From a conventional textbook based education perspective, there have been several pedagogical impact studies on the effect of textbooks and other educational practices [27, 28, 29, 30, 26, 25]. In fact, many of these conventional studies have been performed in the context of developing regions and also exposing the limitations of existing educational resources. Many of these studies have also exposed the limitations of standardized textbooks for education. Recent work by Agrawal et al. that have determined new ways of augmenting and annotating textbooks with Web based educational material [6, 19, 20, 21]. The basic rationale behind these works is similar to the focus of our paper in that the Web has a wealth of educational information that can be used for enhancing textbook content. This paper tries to bridge the gap in terms of quantifying the utility of Web-based content based on teacher and student-centric user studies.

The Hole-in-the-Wall project showed that exposure to Web-based educational resources to under-privileged students without any formal guidance on innovative learning platforms can indeed produce positive learning outcomes [7]. Digital Study Hall is another successful project that has used participatory videos to enhance rural school education [13]. There have also been studies which have analyzed the merits of Powerpoint slides [23] and video materials [35, 14] as teaching aids.

There have been various standardized methodologies for comparing web-based and other computer-based learning with traditional learning and teaching [4, 5]. One of the more popular methods used was Pre- and Post-test comparisons [8]. Another mechanism of evaluating any computer-based educational tool is to compare the performance of two similar group of students, one studying through the tool and another studying the same topics in standard classrooms [2]. We adopt this methodology in our second user study for the content utility problem. Recently, Rafferty et al. [24] have proposed a new mechanism to formulate teaching plans based on students' performance using POMDP planning. We intend to leverage such framework to build adaptable teaching plans in future work.

There have been a wide range of technology-based educational tools that have been proposed and implemented to enhance education in developing regions [9]. These include high-quality content creation [10, 34], online videos [35], leveraging interactive DVDs [3], intelligent tutoring systems [11] and multi-user educational tools [12]. In cases where Internet connectivity is absent in developing regions, regions, researchers have proposed the use of television and DVDs for enhancing participatory education [13, 3, 14]. There were also attempts of giving access to educational web contents in an offline manner to students in rural schools without Internet [15, 16]. The problem has been targeted in a different way by Pal et. al by providing low-cost specialized electronic device to schools to access multimedia content [17]. The MILLEE project have proposes new educational tools for language learning using mobile devices and interactive games [22, 18].

8. CONCLUSIONS

With the growth in Web usage in schools around the school, we believe that there needs to be a better under-

standing of the utility of Web based educational resources in enhancing learning outcomes in schools. In this paper, we analyzed two basic questions in this space: (a) Characterizing the Web content quality; (b) Characterizing the effectiveness of CIP, lesson plans created using web contents in teaching a class. Based on our expert teacher feedback, we find that the benefits of Web based resources are overwhelmingly positive, but also caution on the use of these resources in practice to positively affect outcomes. From the second study, based the teacher' s feedback, we found that the CIP along with the bookmarking tool for lesson plan creation is a useful aid for the rapid creation of teaching lessons, makes teaching more interesting, and students less distracted. As part of future work, we aim to perform a detailed large scale study from the student perspective based on learning outcomes.

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