WEB 2.0 AS AN ENABLER OF DEVELOPING OPEN CONTENT ONLINE HYPERTEXTBOOKS

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ABSTRACT
A *Hypertextbook* is an online version of the traditional textbooks. Different from a hardcopy textbook or an e-book, a *Hypertextbook* in a way is similar to a Web-based system, which provides attractive features such as dynamic interactions, multimedia presentations, animations of important concepts and procedures, and pervasive availability wherever Internet is accessible. *Hypertextbooks* may be adopted in traditional classroom teaching, but distance education and Web-based education in particular can greatly benefit from the dynamic and user friendly features provided by *Hypertextbooks*. In this paper, we report our experience of developing *Open Hypertextbooks*, which combine the merits of *Hypertextbooks* and features provided by Web 2.0 technology, especially the collaborative authoring process and the collective intelligence resulting from that process. The result is an open content online textbook with not only rich features typically available in a conventional textbook but also flexibility allowing user contribution by adding and/or changing the content of the book. In addition to presenting our design of an *Open Hypertextbook* that we developed for the subject Wireless Sensor Networks, in this paper we also survey related work and examine issues that one may encounter when developing a good quality *Open Hypertextbook*.

KEY WORDS
Open Hypertextbooks, Web 2.0, Collaborative Authoring

1. Introduction

It is typically a difficult task to publish a conventional textbook, whether as a hardcopy book or an e-book, while trying to satisfy all types of users' needs. There exist a huge span between different users in terms of their interest, motivation, experience, and level of knowledge.

With the pervasive presence of the Internet in today's society, online publishing has become increasingly popular in various sectors, including the publishing and printing industry. With the growth of the Internet and its myriad of powerful features, some publishers have tried to resolve the aforementioned issue by publishing online textbooks as Web-based information systems, thereby benefiting from the multimedia and interactive nature of Web-based systems. Furthermore, an online textbook allows the publisher to make frequent updates when necessary, and has the flexibility of offering tailored contents for users of different background and capabilities.

One example of online textbooks is the *Hypertextbook*. It is an online version of a textbook which supports features such as high definition images, slide shows, multiple sound tracks and video clips [1]. It also provides information in a non-linear manner and has user-adjusted level of content, which helps different users to access information in a manner suitable for their respective levels [1] [2]. The development of *Hypertextbooks*, however, is typically a closed process, not allowing any user contribution, and therefore does not benefit from the great features provided by Web 2.0 technology [3].

An example of online books that support open content and other Web 2.0 features is the *Wikibook*, which is built upon the Wikipedia platform, a phenomenal Web 2.0 application. The content of a *Wikibook* are contributed by volunteers, in a way similar to how Wikipedia pages are collaboratively edited by contributors. Although *Wikibooks* started as an open-content textbooks project, a close look at the existing examples of *Wikibooks* reveals that most, if not all, of the *Wikibooks* are not really textbooks in the conventional sense, lacking important features such as chapter-end exercises, quizzes, labs, etc. Neither do they provide features available in *Hypertextbooks*, such as user-adjusted level of content and real-time dictionaries.

In this paper, we propose the development of *Open Hypertextbook* - a comprehensive Web-based *Hypertextbook* which offers the flexibility of user contributed knowledge and Web 2.0 services. *Open Hypertextbooks* and *Wikibooks* share many features. For example, both are Web based, support multimedia contents, and allow user-contributed knowledge. The *Open Hypertextbook*, however, provides features desirable in a conventional textbook, such as chapter-end exercises, quizzes, labs, real-time dictionary, and tailored user levels,

which are not features present in *Wikibooks*. Our focus in this paper is twofold. First, we provide brief surveys of concepts related to *Open Hypertextbooks*, including *Hypertextbooks*, Wikipedia, and *Wikibooks (section 2)*. The issues one may encounter in developing an open content *Hypertextbook* are examined in section 3. By combining the features of *Hypertextbooks* and Wikipedia, we present the design of a sample *Open Hypertextbook* for Wireless Sensor Networks (section 4). Section 5 concludes the paper with further discussions.

2. Related Work

In this section, we give brief surveys of projects that are related to the development of *Open Hypertextbooks*. Figure 1 illustrates that *Open Hypertextbooks* derive features from both Wikipedia and *Hypertextbooks*.

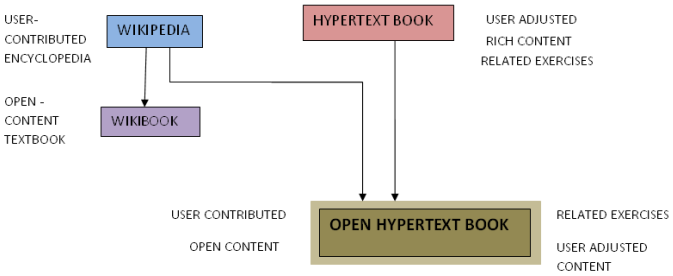

Figure 1. Relationships between *Open Hypertextbook* and Related Concepts

2.1. WIKIPEDIA (as an example of Web 2.0 applications)

Among the many popular Web 2.0 applications (for example, MySpace, Facebook, YouTube, Flickr, etc.), Wikipedia stands out with its support for *collaborative editing*, which allows all users to participate in creating and editing articles in the online encyclopedia. The result is the world's largest and most popular general reference work on the Internet[1]. The Wikipedia phenomenon demonstrates how *collective intelligence* may be generated in large scale with support provided by Web 2.0 technology, which solicits world-wide user contributions.

As summarized by O'Reilly [4], a Web 2.0 application exhibits some (if not all) of the following characteristics:

- In Web 2.0 applications, it is the *services* (and not the packaged software) that are generating the revenue for the organizations.
- A Web 2.0 application tends to c*ontrol over unique, hard-to-recreate data sources* that get richer as more people use them. Users become *stuck* to the application when more unique data are available in the application.
- Web 2.0 applications t*rust users as co-developers***.** First of all, the feedback from the users helps the developer and/or the organization to make the product better; in many cases, the users are actively involved in the development process. The result is the *collective intelligence* (see below).
- The collaborative services provided by the Web 2.0 site facilitate and enable user contributions. Therefore, a Web 2.0 application tends to *harness collective intelligence*.
- Another unique principle of Web 2.0 applications is that they tend to *leverage the long tail through customer self-service*; by making their Web sites and online services user friendly and easy to use, they reap the benefit of more customers using their services (for example, Google search engine) and the advertisement revenue that follows.
- Web 2.0 applications tend to be supported by *software above the level of a single device*. That is, the software work on different devices and different client platforms while delivering the same quality and performance.
- Web 2.0 applications tend to adopt *lightweight* user interfaces, development models, and business models. A *lightweight* entity is simple and elegant. A lightweight user interface, for example, does not consist of heavy graphics. A lightweight model tends to employ multiple, simultaneous processes to achieve a common goal.

Wikipedia is essentially a free multilingual online encyclopedia[1]. The most unique feature of Wikipedia is that it allows anyone on the Internet to change and update the content, following Wikipedia's collective editing policy to reach consensus. This feature can be both useful as well as harmful for the cause of Wikipedia. With this feature, the content on Wikipedia pages is derived and updated by various users and this can be really useful in improving the content of the article. Since it allows anyone to edit the content, there are various issues such as plagiarism, wrong or ambiguous information, and inaccurate or incomplete information, all of which need to be properly addressed in order to assure the quality of the pages. To serve this purpose, volunteers (working as moderators and authors) are in charge of specific topics and sections within a topic; those volunteers constantly keep track of the authenticity and correctness of information added to the pages [5]. However, Wikipedia, being an encyclopedia, only imparts general information and does not thoroughly cover a specific topic as is typically done in a textbook.

2.2. *HYPERTEXTBOOKS*

A *Hypertextbook* is a computer-based and comprehensive online resource, which promotes active learning [1] [2]. A *Hypertextbook* contains multimedia features such as high

definition images, video clips, slides, etc., which make it more interesting and attractive to the readers. A *Hypertextbook* may adopt Java programs (applets), which are embedded seamlessly in the *Hypertextbook* and provide dynamic user interface such as animation [1]. Another important feature of *Hypertextbooks* is real-time dictionary. When a user clicks on a word, relevant information or definition of that word is displayed [2]. These dynamic and interactive features of *Hypertextbooks* are typically not present in conventional textbooks. In addition, a *Hypertextbook* contains various other features typically present in a conventional textbook, including self-test quizzes with feedback, chapter-end exercises, labs, etc. Figure 2 illustrates those features in a sample *Hypertextbook* for the subject *Biofilms*.

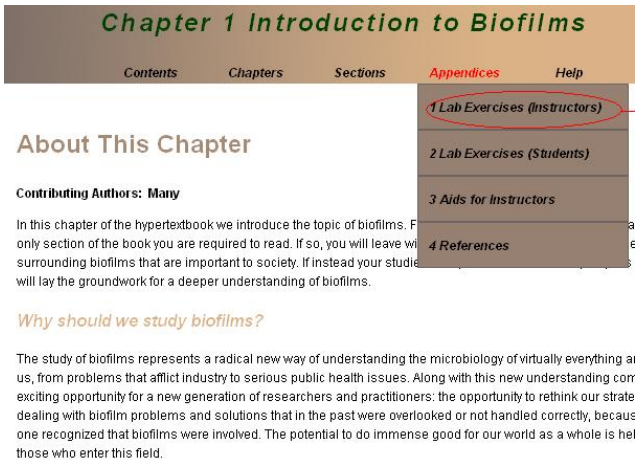

Figure 2. A snapshot of the *biofilm* hypertextbook, with chapter-end lab exercises and other features [1]

Hypertextbooks provide information in a non-linear manner in which the user can decide what to visit next and access related information using the linked documents. As shown in Figure 3, it provides with an option for different user levels, by providing tracks for novice, intermediate, and advanced users through the sections. It tailors the content depending on the level selected by the user. Based on studies by Cunningham and Ross [2], students have good learning experiences using *Hypertextbooks*, and they perform better in learning the subject.

For authors who want to develop a *Hypertextbook*, an authoring environment is provided; however, as reported in [2], instructors who are not technically savvy may find it initially difficult to master that environment. In addition, the authors, as those writing a conventional textbook, need to put in extra efforts and time in search of good visualizations, images and content materials related to the respective subject [2]. Moreover, the authoring process of a *Hypertextbook* is a closed process, not allowing user contributions.

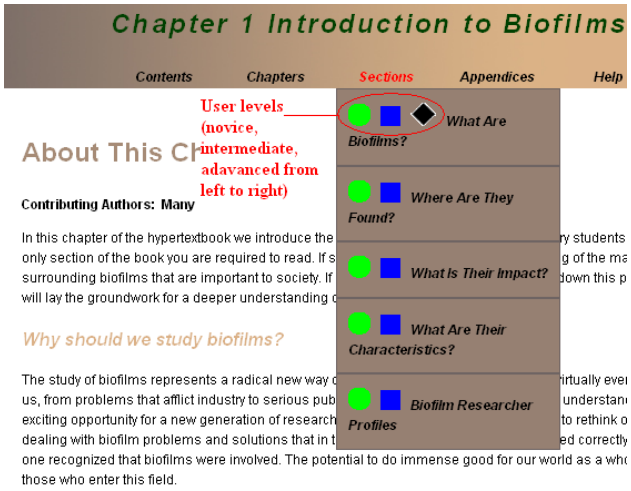

Figure 3. User levels in the *biofilm* hypertextbook [1]

2.3. *WIKIBOOKS*

Developed as a sister project to Wikipedia, *Wikibooks* has grown rapidly since its creation in July 10, 2003[2]. As of June 25, 2009, there exist over 38,000 pages and over 245,500 users registered with *Wikibooks* website[3]. In addition there exist about 900 active users (users who performed an action in the last 30 days) [3].

At the core, a *Wikibook* is an open-content online book that allows user contribution[4]. Volunteers who contribute to the writing of *Wikibooks* are called *Wikibook*ians. *Wikibooks* modules passed the 10,000 modules milestone after only two years of operation[2]. The content of a *Wikibook* is constantly improving as long as it continues to attract more *Wikibook*ians to help update the content by augmenting their inputs to the content. Similar to Wikipedia, some volunteers (as *authors*) are in charge of creating a *Wikibook*, while others (as *co-authors*) are in charge of checking the accuracy of updated information [6]. In addition, *Wikibooks* also have a version control feature which allows keeping track of versions of the changes. Figure 4 illustrates a sample *Wikibook* for Ecology.

Wikibooks provide various multimedia. These multimedia features along with the user involvement allow *Wikibooks* to be an interesting and innovative learning resource.

Although *Wikibooks* started as the "open-content textbooks" project[2], the existing *Wikibooks* lack important features typically available in a conventional textbook. If a *Wikibook* is to be used in a classroom setting, features such as labs, assignments and quizzes must be provided to help the students understand the subject matter. Without these fundamental features, a *Wikibook* can hardly be called an online textbook.

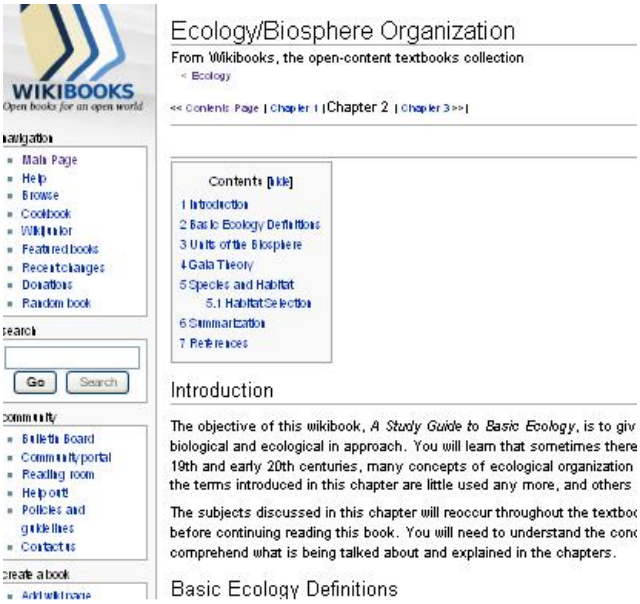

Figure 4. An example Wikibook for ecology (from http://en.wikibooks.org/wiki/Ecology/Biosphere_Organization)

2.4. Comparison of *Wikibooks*, *Hypertextbooks*, and *Open Hypertextbooks*

As discussed earlier, we can infer that *Wikibook*s and *Open Hypertextbooks* serve the same purpose, in the sense that both try to render online books. They share most of the features in common including high definition images, video clips, user contribution, etc.

Table1. Comparison of *Open Hypertextbooks* with *Wikibooks* and *hypertextbooks*

Features	*Open Hypertextbooks*	Wikibooks	Hypertextbooks
Main use	Classes	General public	Classes
High definition images	Yes	Yes	Yes
Video clips	Yes	Yes	Yes
User contributed content	Yes	Yes	**No**
Levels of users	Yes	**No**	Yes
Teaching notes	Yes	**No**	Yes
Chapter-end exercises	Yes	**No**	Yes
Self-test Quizzes	Yes	**No**	Yes
Labs (Projects)	Yes	**No**	Yes
Supplements for Teachers	Yes	**No**	Yes
Real- time dictionary	Yes	**No**	Yes

As shown in Table 1, *Open Hypertextbooks* have various additional features which make it more effective and versatile than *Wikibook*s. For example, *Open Hypertextbooks* have user adjusted content, in which each section is divided in three tracks: novice, intermediate and advanced users, respectively. Therefore, it may adapt to the different levels of users and help learning the topic more effectively. *Wikibook*s do not support any similar features to adapt to the level of users. Another set of distinct features of *Open Hypertextbooks* include chapter-end exercises combined with quizzes and labs, which are typically available in a conventional textbook for students and instructors to use. These features, absent in *Wikibook*s, are important in helping students to understand the topic.

3. Challenges of developing *Open Hypertextbooks*

Both *Hypertextbooks* and *Wikipedia* have certain advantages and disadvantages. The *Hypertextbook* is based on HTML and have built-in features such as cascading style sheets, a common file structure, video clips and a set of JavaScript functions. On the other hand *Wikipedia* is built on MediaWiki, which is Web-based wiki software written in PHP. There are two major challenges to overcome while combining open nature of *Wikipedia* with *Hypertextbooks*.

3.1. How do we retain the rich media types currently in Hypertextbooks when moving to the MediaWiki platform?

The *Hypertextbook* supports various multimedia features, which make it more effective and interesting to the users than a traditional textbook. It supports various formats of images, animations, audio, and video content. In addition, it supports adjustable user levels and a real-time dictionary. It is essential that all these multimedia and user interaction features are retained in the *Open Hypertextbook*.

By default *MediaWiki* supports gif, jpg, jpeg and png image formats[5]. Therefore it supports most of the standard image formats. It also supports embedding of most of the standard audio formats, such as mp3 and ogg[6]. In addition, it supports various video formats, including flash, QuickTime, etc. Embedding of videos from popular sites such as YouTube, Google video and other sites is also supported[7].

Another important feature in *Hypertextbooks* is user levels, which adjusts the content according to the type of the users (novice, intermediate, or advanced). This feature can be incorporated with the MediaWiki platform as it supports JavaScript and HTML, which can be used to support this feature[8]. The real-time dictionary feature may also be supported in the same manner in *Open Hypertextbooks*.

Along with the support of these multimedia features, MediaWiki also provides various other useful features. It supports user contribution and hence increases user-involvement. It also has discussion and history pages for

each article, allowing users to know more about the recent changes and updates on the article. It provides registered users with extra features such as keeping track of a certain page of interest to the user.

Based on our investigation, we conclude that MediaWiki is able to provide a development platform that allows the developers of online textbooks to retain the rich types of content of *Hypertextbooks*; furthermore, MediaWiki provides additional useful features to improve the learning process for the users.

3.2. How do we maintain the quality of the content required of an online textbook when moving to the open content environment of MediaWiki?

As the user will be allowed to make changes to the content of an *Open Hypertextbook*, it is necessary that the quality of the content is maintained. For that, a good mechanism must exist to ensure the quality of the content. In most wiki-based systems (e.g., the Wikipedia), the quality of content is maintained by two primary mechanisms: the collaborative editing process and the peer review process.

The collaborative editing process involves administrators and other volunteers who actively take part in the improvement and maintenance of the article. It involves various users, who take up responsibilities of updating the content and/or ensuring the correctness of the pages. These changes are discussed by the community in the discussion page with the focus mainly being on whether the changes do improve the content, are they objectionable and whether they comply with all the guidelines. There has to be a consensus reached among the community on this topic and may require some compromise at times to reach a consensus of majority and for changes to be accepted.

This collaborative editing process, however, does not assure that quality of content will be preserved all the time. It is quite possible that, in collaborative editing, there may be unwanted or even harmful changes made and they may remain for some time before being noticed and reverted.

Peer reviews in Wikipedia are performed by people who contribute or edit the content (also known as *Wikipedians*). To improve the quality of an article (e.g., from a start level to a more improved standard), the article can be nominated for peer review. In Wikipedia a quality scale has been developed to assess the article based on certain criteria and to categorize it in its respective standard[9]. On this scale, starting with the most improved to the least effective, values such as FA, A, GA, B, Start, Stub and List may be assigned to an article[9]. FA (i.e., Featured article) designates the highest standards in terms of its content, while a *stub* or *list* represents the lowest value and the article usually has only a few sentences regarding the subject. The assessment of an article's quality is also performed by Wikipedians, who follow the guidelines laid down by the Wikipedia community[10, 11].

Open Hypertextbooks will follow similar quality control mechanisms as in Wikipedia, i.e., collaborative editing and quality scale. In addition, one or several of the following measures may be implemented to further ensure the quality of *Open Hypertextbooks*:

(a) One of the *alternatives* of securing the editing process is to increase the granularity of security for the various parts of an article. Pages may be protected and only portion of the pages may be changed to ensure that the structure and the core content of the article are preserved. To achieve this, finer access control features is needed.

(b) Another option is to assign some responsibilities (e.g., maintenance of a certain article) to certain person(s), instead of all the work being voluntary. Similar to option a, finer access control of the pages is needed to support this option.

(c) A third option is to add *expert* peer reviews to help produce high quality articles. As discussed above, peer reviews in Wikipedia are typically not performed by *experts* in that subject as peer reviews of research articles are typical carried out[12]. Inviting well known *experts* of a given subject to review the article will definitely help to further improve its quality.

4. An *Open Hypertextbook* for Teaching Wireless Sensor Networks

As illustrated in Figure 5, features of the *Open Hypertextbook* for Wireless Sensor Networks are derived from Wikipedia and *Hypertextbooks.*

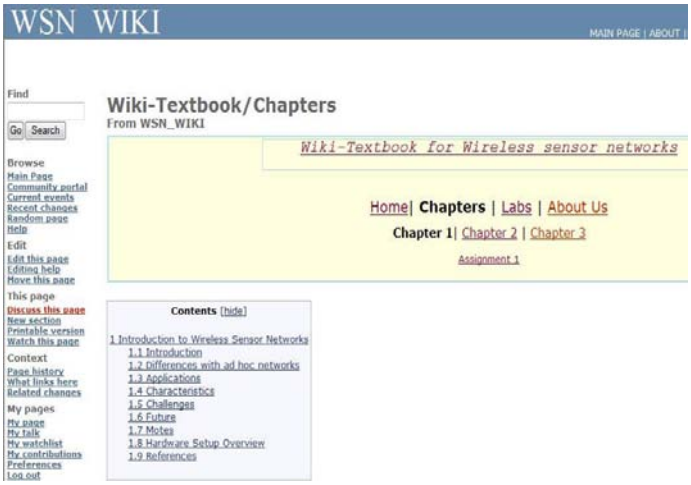

***Figure 5. Open Hypertextbook*: WSN: Chapters**

It inherits many features from both projects. For example, some of the *Hypertextbook* features like high definition images, video clips, self-test quizzes, chapter-end exercises etc., are also available in *Open Hypertextbooks*. In addition,

it inherits the open and user contributed nature of Wikipedia. An *Open Hypertextbook*, with these combined features, increases the user involvement by allowing users to contribute to the content of the book.

As an experimental development of *Open Hypertextbooks*, we have developed the prototype of an *Open Hypertextbook* for the subject *Wireless Sensor Networks*. As shown in Figure 5, the *Open Hypertextbook* consists of three primary tabs (Chapters, Labs, and Assignments), plus several additional tabs. The *home* tab gives a brief description of the various chapters in the book. The *About us* tab provides information about the authors of the *Open Hypertextbook*. Each chapter under the *Chapters* tab gives a brief description of the particular topic covered in that chapter. The user is provided with an index of topics related to that particular chapter. The index feature is built into MediaWiki, making it easy for the user to navigate through the different chapters.

Also illustrated in Figure 5 is the *assignments* tab. Each chapter has its related set of assignments and can be viewed with the tab provided underneath the list of chapters. Figure 6 illustrates an example assignment for the Wireless Sensor Network *Open Hypertextbook.*

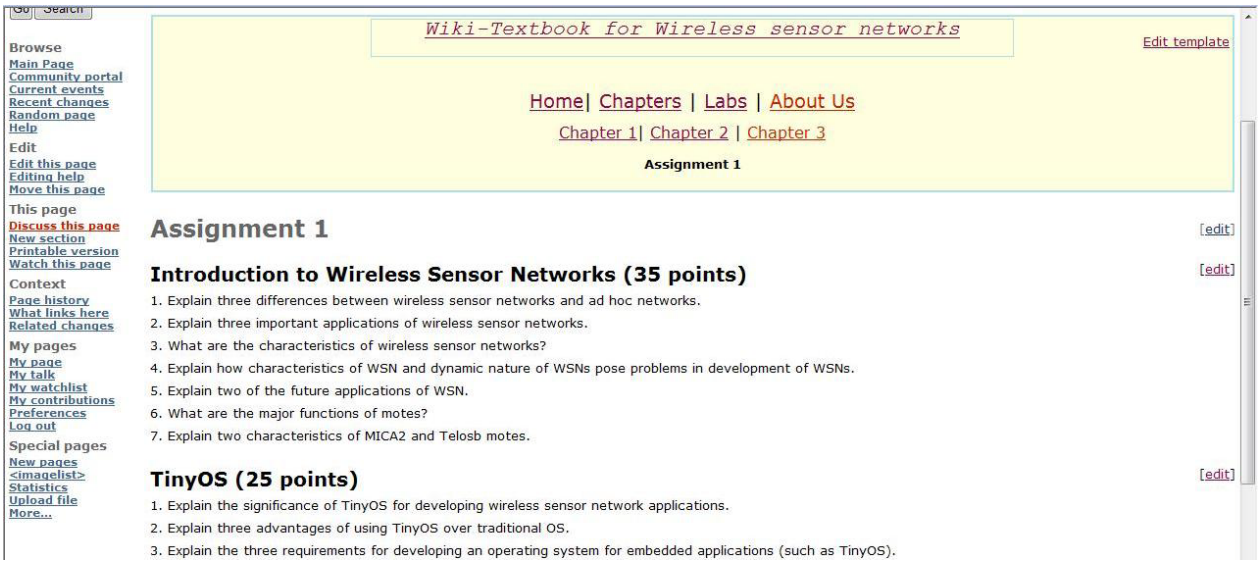

***Figure 6. Open Hypertextbook*: WSN: Assignments**

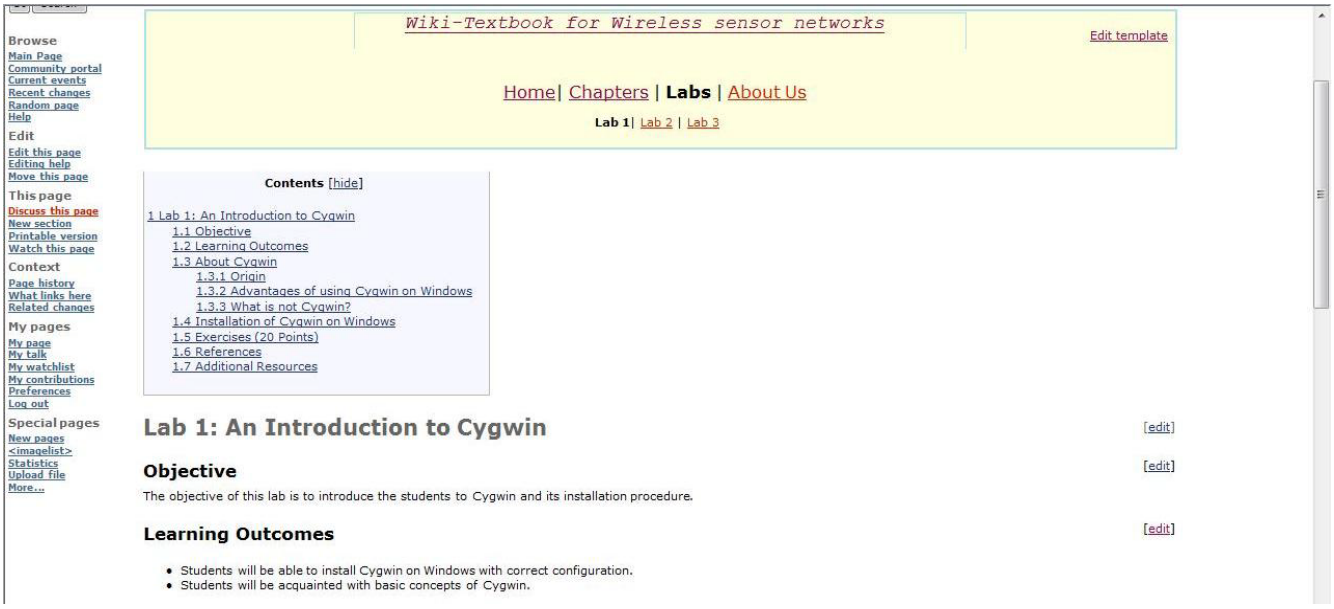

***Figure 7. Open Hypertextbook*: WSN: Labs**

The *labs* tab provides an in-depth description of lab experiments, which serve as tutorials of related concepts and skills. It consists of screen shots and various images related to the lab exercises, making it easier for the user to understand the particular lab. The lab typically contains step-by-step software installation instructions, issues with the installation, and references to related information. Completing the labs enables the user to be acquainted with installation of the required software and basic terms of Wireless Sensor Networks. Figure 7 illustrates an example lab, lab 1: Introduction to Cygwin.

The *Open Hypertextbook* of Wireless Sensor Networks currently consists of four chapters and four labs. Each chapter consists of a corresponding set of assignments and exercises. We are currently working on the *user levels* option, aiming at providing different tracks (novice, intermediate and advanced) of the sections for users with different background of the subject.

5. Discussion and Future Work

In this paper we briefly survey Wikipedia, *Wikibooks* and *Hypertextbooks*, which all aim at providing online resources for learning. We propose combining the open nature of Wikipedia with features of *Hypertextbooks* to create *Open Hypertextbooks*, which provide a free and improved learning resource for educational purposes. Issues related to the development of *Open Hypertextbooks* are examined. Features implemented in a sample *Open Hypertextbook* (for the subject of Wireless Sensor Networks) are discussed.

The anticipated educational impact of *Open Hypertextbooks* on technology-based education and professional training include the following:

(a) *User community:* The collaborative authoring process of creating and updating an *Open Hypertextbook* will facilitate the forming of a user/author community with shared interest in a particular subject area (e.g., Wireless Sensor Networks). In addition to subject experts, the community will also be composed of instructors teaching relevant subjects and students taking classes in those subject areas.

(b) *Constant updating:* A well designed *Open Hypertextbook* will provide attractive features that are not available in a hardcopy or electronic textbook. In addition to interactive features typically provided by Web-based information systems, an *Open Hypertextbook* supports dynamic participation of all parties (authors and users alike), which results in collective intelligence formed out of user contributions. Instead of waiting for the author to correct an error in the next revision (as in the traditional textbooks), an *Open Hypertextbook* can be constantly revised, therefore promptly removing errors detected by the users and incorporating up-to-date information into the online textbook.

(c) Involved and happy instructors: A common dilemma facing most Computer Science and some Engineering instructors is the frequent need to change the textbooks. This is mainly the result of the still evolving nature of the subject areas. The subject *Wireless Sensor Networks*, for example, is still an evolving research area, with many new algorithms and tools constantly added. A typical Computer Science textbook, especially in advanced research areas, is likely to become out-dated in less than three years. When the instructor decides to change the textbook in a course, it is likely necessary for the instructor to update most of the teaching materials, including lecture notes/slides, assignments, and projects. Because of the *constantly updating* feature of an *Open Hypertextbook*, the instructor who adopts an *Open Hypertextbook* in his/her course does not need to deal with the dilemma of whether to change the textbook or not every two or three years.

(d) Cheaper or free textbooks: A common complaint of today's college students, especially those in Computer Science, Engineering and Business areas, is the high price of textbooks. A typical Computer Science textbook, for example, can easily go above $100, and some instructors assigned two or more textbooks because they are not able to find a single textbook suitable for their courses. With its open content and user contribution features, an *Open Hypertextbook* represents the collective intelligence of all who have contributed, implying that the *Open Hypertextbook* will be offered free to all or, if a fee is charged, for a very small cost.

(e) Motivated students: A user of an *Open Hypertextbook* is encouraged to develop him/herself from being a novice in the subject area to eventually becoming an expert contributor to that *Open Hypertextbook*. Although it is not practical to expect all students to evolve this way, it is feasible that a great number of students will be motivated to contribute to the content of the *Open Hypertextbook* that is adopted by his instructor as the textbook for the class.

As part of our future work, we plan to empirically verify the anticipated impact described above. In addition, we will continue to implement advanced features of the *Open Hypertextbook* for Wireless Sensor Networks, such as user levels, real-time dictionaries, and innovative content review process. Besides, in order to ensure long-term sustainability of *Open Hypertextbooks*, feasible business models for open content online resources need to be examined and adopted. Although online advertisement is the most common form of supporting free online resources [3], currently *Wikipedia* is solely funded by donation. With *Open Hypertextbooks*, in addition to the donation model, other business models may be feasible. For example, when a typical Computer Science textbook can easily cost $100 or more, would users be willing to pay a small fee ($15-$30 dollars) in order to use the content of the *Open Hypertextbook*? What would be the potential impact of a fee-based model on the open content

nature of *Open Hypertextbooks*? Issues such as those need to be further studied.

Acknowledgment

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End Notes

[1] HTTP://EN.WIKIPEDIA.ORG/WIKI/WIKIPEDIA

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[8] http://www.mediawiki.org/wiki/Extension:Javascript

[9] http://en.wikipedia.org/wiki/Wikipedia:WikiProject_Books/Assessment#Quality_scale

[10] http://en.wikipedia.org/wiki/Wikipedia:Featured_articles

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