

ENWiC: VISUALIZING WIKI SEMANTICS AS TOPIC MAPS

An Automated Topic Discovery and Visualization Tool

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Abstract: In this paper, we present ENWiC (EduNuggets Wiki Crawler), a framework for intelligent visualization of Wikis. In recent years, e-learning has emerged as an appealing alternative to traditional teaching. The effectiveness of e-Learning is depended upon the sharing of information on the web, which makes the web a vast library of information that students and instructors can utilize for educational purposes. Wiki's collaborative authoring nature makes it a very attractive tool to use for e-Learning purposes; however, its text-based navigational structure becomes insufficient as the Wiki grows in size, and this backlash can hinder students from taking full advantage of the information available. ENWiC's goal is to provide student with an intelligent interface for navigating Wikis and other similar large-scale websites. ENWiC make use of graphic organizers to visualize the relationships between content pages so that students can gain a cognitional understanding of the content as they navigating through the Wiki pages. We describe ENWiC's automated visualization process, and its user interfaces for students to view and navigate the Wiki in a meaningful manner, and for instructors to further enhance the visualization. We also discuss our usability study for evaluating ENWiC's effectiveness as a Wiki Interface.

1 INTRODUCTION

Wikis and blogs are becoming increasingly popular means of on-line communication, collaboration and information sharing. As of October 12, Wikipedia (Wikipedia) contains over 2M articles in more than 20 languages and the numbers increase daily. Furthermore, an abundance of domain-specific wikis exist on a variety of topics, such as for example computing science (<http://c2.com/cgi/wiki>, <http://wiki.java.net/bin/view/Javapedia/WebHome>), image sharing (<http://www.openclipart.org/cgi-bin/wiki.pl>), etc.

The collaborative nature of information publishing in Wikis makes them a convenient tool for e-Learning purposes. Wikis are an ideal medium for instructors and students to interact. It is easy to add and modify Wiki content and to establish links between Wiki pages. This ease of use strongly encourages users to contribute content, giving the Wiki an incredible wealth of information. However, this wealth does come at a cost: the more pages a Wiki has, the more difficult it becomes to navigate through it. It is common for a Wiki page to contain a sizable number of links in its body text. Users have to read through the text to locate these links and to guess what the next appropriate pages might be. It is also easy for users to feel "lost" after having gone

through a number of links, since the standard wiki interface does not provide any navigation context. Furthermore, the nature of the relationship between a page and its neighbors is not always intuitive, since wikis do not impose any requirements on what links are appropriate and do not support any metadata for link annotation. To alleviate this problem, some Wikis provide special purpose pages, such as roadmaps, categories, and lists of back links. However, it is not immediately apparent to the users how to utilize these pages; novice wiki users, especially, may not even be aware of the purpose and usage of such pages. Even these special-purpose pages are typically overwhelmingly long lists of text links.

The objective of this work is to provide a more intuitive user interface to wikis, in order to take advantage of the large information repositories that they provide. We are especially interested in supporting student usage of wikis offering technical content. Students accessing these wikis need an easy-to-learn and easy-to-use interface that will enable them to effectively locate information relevant to their tasks and, in the process, to achieve a deeper understanding of the concepts presented in the various wiki pages.

The ENWiC (EduNugget Wiki Crawler) tool builds on the EduNuggets framework (Stroulia &

Jari 2003) and represents the structure of a Wiki as a topic map (TopicMaps). A topic map models the semantics of an application domain in terms of topics, associations and their instances. Thus, it imposes a structure to the domain data, which can also provide the basis for a graphical visualization. A web crawler is used to automate the topic-map creation process, while further refinements can be made by authoritative experts – such as instructors or wiki moderators - to add concepts and structure to the topic map. Since graphic organizers have been shown to be useful in assisting students in learning concepts and identifying relationships between concepts (Amin 2005; Robinson & Skinner 1996), we visualize the Wiki topic map as a graph to help students navigate the Wiki. By defining different types of associations in the topic map, different types of graphic organizers can be created to service each cognitive domain defined in Bloom's taxonomy (Bloom 1956; Donelan). This will help students achieve different levels of understanding of the content faster than using only indices and text of the Wiki.

The rest of the paper is organized as follows: Section 2 will talk about related research; Section 3 will describe the goals and ideals of ENWiC and give an overview of the program; Section 4 will cover the details of the program; Section 5 will discuss the experimentation we ran with ENWiC; and finally, we will conclude what we have discovered for ENWiC.

2 RELATED RESEARCH

Touchgraph (TouchGraph) released a Wiki browser for the Meatball Wiki and the Emacs Wiki to demonstrate their toolkit. It uses the link database of a Wiki to create the graph. The downside to this browser is that it will only work with Wikis that have a link database, and there is no easy way to manipulate the graph if a user wishes to do so.

TM4L (Topic Map For Learning) (Dicheva, Dichev & Wang 2005) provides an editor and a viewer for topic maps, designed for e-Learning purposes. It provides pre-defined associations, relationships and topic types to allow for easy creation of learning content. It also supports user-defined association types as well. The Viewer visualizes the topic map in a graph or a tree, but it does not provide a browser to let user directly access the URIs that a topic node may contain.

The Platypus (Campanini, Castagna & Tazzoli 2004) and SHAWN (Aumueller 2005) tools use semantic-web technologies to describe the ontology of a Wiki. Both utilize RDF (Resource Description Framework) metadata to structure and organize the

Wiki content. In the Platypus Wiki, users are provided with a standard Wiki editor and a companion metadata editor for each Wiki page. Users can set up a site link table which maps a keyword to a URL; when another user writes a Wiki page, the tool will automatically look for keywords from the site link table and convert them to links to the corresponding URLs. When viewing a page, the metadata is shown in a side panel to help with navigation. In SHAWN, users can edit both the metadata and the content of a page in the same editor. SHAWN automatically displays forward links and pages with relating metadata based on the triplets entered by the author(s) of the page.

Smith (Smith & Fiore 2001) developed a set of visualization tools for Usenet. Usenet can grow to contain a very large number of messages, and like a Wiki, a typical Usenet client just does not have an adequate organization and navigation structure to effectively convey the ontology of the messages. Smith uses a number of information types - such as the history of a thread and the participation history of each user – to create a variety of views to represent the threads in a newsgroup.

Canas and his colleagues (Canas et al. 2005) described how concept maps, a type of graphic organizer, can visualize 'knowledge' which will assist users in organizing information and searching information on the web. Their CmapTools represents knowledge as concepts and propositions in a map. CmapTools utilizes the concept maps to enhance web search; a user can simply click on a concept node, and search queries are generated based on relating concepts and authority concepts. After executing the search, the results are ranked based on the distance matrices from the map.

Like CmapTools, VisSearch (Lee 2005) uses a graph to enrich search results. Users create a search graph that contains query nodes and associations between them. The search graph can be reused; users can select multiple nodes, which will combine the existing queries to form a new query. Users can also associate relevant bookmarks to a query node as a means of organizing useful links. VisSearch also takes advantage of search results from multiple users to recommend potentially useful sites. A VisSearch server takes search results from users with similar interests and analyzes the data so that when another user searches for similar information, it can determine what results may be interesting to the user.

3 ENWiC REQUIREMENTS

The primary objective of our work with ENWiC is to provide an intuitive interface for users to effectively navigate the Wiki structure to find

information relevant to their tasks. The ENWiC Viewer provides an interactive graphical interface that visualizes the Wiki as a topic map. There are two intuitions behind the ENWiC design, aimed to support this objective. First, the ENWiC topic map provides an overall view of the wiki organization structure, thus enabling users to maintain a mental model of their browsing history and current context. The topic map can be visualized at different levels of detail, so that users can control the amount of information presented to them. Second, the ENWiC graphic organizers represent distinct types of substructures, easily recognizable by the users who may choose to focus on them when they correspond to the types of relations they are interested in. Finally, as with the standard wiki interface, users can always jump to a specific topic using a search function, instead of browsing through the graph.

In addition to this primary functional requirement, ENWiC was designed with the following quality requirements in mind:

1. *Implementation independence*: Most graphical wiki interfaces (Touchgraph, Platypus and SHAWN) assume a particular Wiki implementation. ENWiC works with all Wiki implementation.
2. *Automatic topic-map discovery*: The topic-map representation of the Wiki is generated automatically, based on the wiki-pages hyperlink structure. In addition ENWiC attempts to discover domain-independent relations, such as linear topic sequencing or hierarchical topic dependencies, in order to embed in the topic map distinct graphic organizers that can assist users to navigate and understand the visualization better.
3. *Easy authoring of domain-dependent semantics*: ENWiC provides a simple tool to add domain-dependent graphic organizers to provide more semantics to the visualization.

To meet the first two requirements, ENWiC includes a crawler that traverses the wiki pages. The crawler examines the HTML tags of each page to extract links and emphasized text such as header texts. Links are followed to discover the complete Wiki content pages and are treated as associations between the “neighbouring” pages. Emphasized text elements in a page are used as key terms for the content page, and they are also used to classify links.

The third requirement is achieved by offering instructors an authoring environment that allows them to modify the crawler-discovered topic map to enrich its content. Wizards are also provided to guide them through the graphic organizer creation process.

3.1 Bloom’s Taxonomy Graphic Organizers

The design of ENWiC is largely inspired by the use of graphic organizers in support of learning. Graphic organizers such as spider maps, hierarchical diagrams and charts can persuade students to engage in a different kind of thinking instead of just comprehending from text (Lamb 2001). Graphic organizers let student see the ‘bigger picture’ instead of just a part of the content. This addresses the problem with a standard Wiki, where the action of clicking through discrete pages only exposes parts of the Wiki to the users.

Bloom’s taxonomy (Bloom 1956) describes six different levels of cognitive understanding that a learner can gain on a subject. Mastery at the *knowledge* level implies a learner’s ability to recognize and recall information on the subject. Mastery at the *comprehension* level is accomplished when the subject has grasped the domain’s semantics and can interpret and analyze facts to infer conclusions and make predictions based on them. At the *application* level, the learner is able to apply the knowledge in new contexts. A learner who has mastered a domain at the *analysis* level can see patterns and implicit organization in the domain structure and at the *synthesis* level he is able to generalize from the give fact and apply knowledge from many areas to construct new information. Finally, at the *evaluation* level, the learner can assess presentation and theories about the domain.

Donelan (Donelan) relates a taxonomy of graphic organizers to Bloom’s levels of understanding.

- a) At the knowledge level, *spider maps* and *linear strings* support the learners’ ability to remember basic facts on the subject.
- b) At the comprehension level, *hierarchy diagrams* enable them to understand the semantic organization of the domain concepts.
- c) At the application level, *flow charts* guide learners to apply known facts to solve problems.
- d) At the analysis level, *fishbone* and *concept maps* reflect the learners’ ability to explain facts.
- e) *Idea map* – at the Synthesis level - reflects the ability to combine known facts to form solutions for problems.
- f) *Double-cell diagrams* and *comparison matrices* - at the Evaluation level - reflect the ability to rate concepts and information.

ENWiC supports all these Bloom’s graphic organizers. The underlying intuition is that when these organizers are used to present the domain

knowledge visually, the learners can pick up the visual clues and accomplish a deeper level of mastery faster. The ENWiC crawler automatically builds different types of associations among topics and the ENWiC viewer visually reflects these relations. Additional graphical organizers can be created using the ENWiC administration tool.

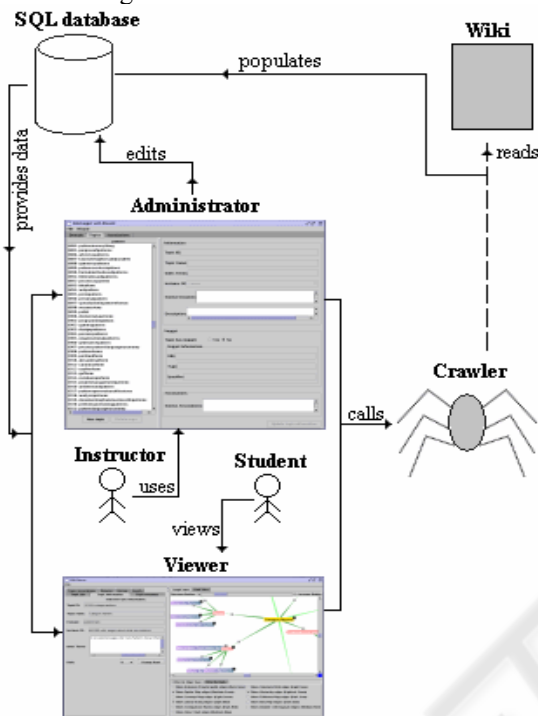


Figure 1: Overview of the ENWiC architecture.

4 THE ENWiC SYSTEM ARCHITECTURE

As shown in Figure 1, the ENWiC system consists of three major components: the *viewer*, the *crawler*, and the *administrator*. The crawler, given a home page, visits all Wiki pages and produces a topic map based on the data it discovers in the pages. Using the topic maps produced by the crawler, the viewer provides a graphical interface to the original wiki content. The administrator enables authoritative content providers to add and edit topics and associations to the crawler-produced topic maps. The administrator component is designed for instructors to use if they wish to provide students with extra semantics to the topic maps produced by the crawler, while the viewer application is designed for students to study the available Wiki domains and navigate through the topics.

4.1 The Crawler

Given the URL of a web-site homepage, the ENWiC crawler traverses all the Wiki pages by extracting the hyperlinks included in each page. Each traversed page is stored in the ENWiC database as a topic under a domain specified by the user to correspond to the web site. Links between pages are marked with an 'instance of' relationship; thus, the path that the crawler has traversed to discover a page starting from the initial URL can be found by examining the linear sequence of the 'instance of' relationships. Since there are multiple alternate paths to a page that the crawler may discover as it examines more pages, the crawler marks these alternate links as associations. They are displayed in different colours in the Viewer so the users can identify them as alternate paths.

Each page usually contains several segments, separated from each other with bold-face headings. The crawler attempts to classify them so that they can be visually presented in a more organized manner. This is accomplished by extracting the text encapsulated in HTML header tags on a page. Each extracted header is made into a topic, and links that fall under that header become associated with that header's topic in the topic map. In the application, the header topics have the text 'SECTION' in their names to indicate that they only account for a section of a page, and not the full page. In the graph, their nodes are coloured differently from the regular page nodes.

For each page discovered, the crawler uses the title of the page, the text of the link leading to the page, and the header text to create the topic's name and index terms. The crawler also ranks each page according to the number of links going to the page (link-in rank), and number of links going out of the page (link-out rank). The rank information is also visualized by the Viewer in order to help students identify which pages may be more useful; if a page is linked by many other pages then that page may contain some very useful information, and if a page has many links going out then that page may be a good index of relating pages.

4.2 The Viewer

The Viewer consists of two main components:

1. A visualization panel that displays a graph to represent the Wiki domain.

2. An information panel that provides: a master list of topics in the domain; information on the selected topic in the graph; a browser that displays the selected topic's Wiki page; a search function; and a history of recently visited topics.

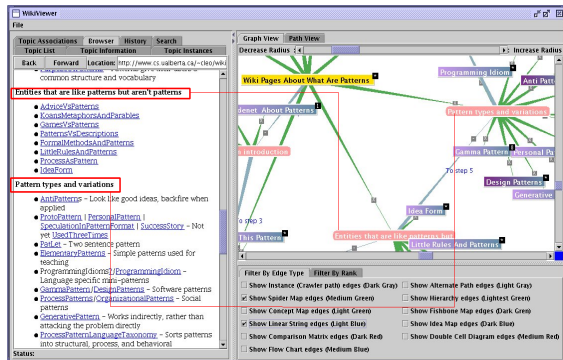


Figure 2: The ENWiC Viewer. Blue/purple nodes represent page nodes while pink nodes represent sections of a page. The yellow node is the currently selected node.

The Viewer takes the topic information from the database to create a XML topic map. The topic map is visualized using the Touchgraph (TouchGraph) toolkit. Topic nodes that represent pages are drawn as a rectangle while nodes that represent sections are drawn as a round rectangle. Page nodes are coloured based on rank; a gradient paint of purple and blue is used to represent the link-in rank and the link-out rank respectively. A deeper colour indicates a higher rank. Figure 2 shows the Pattern Roadmap page of the Portland Pattern Repository's Wiki (<http://c2.com/cgi/wiki?WikiPagesAboutWhatArePatterns>) as seen with the ENWiC viewer.

Edges are coloured and annotated based on the type of association. The user can select which type of edges to show to single out diagrams of interest, as shown in Figure 3.

The Viewer is equipped with a search function so that users can directly look for topics of interest and jump to the corresponding node in the graph immediately. This is useful when the domain has a large number of topics and users may not be able to locate specific topics in the graph readily. The search function will allow them to isolate the desired topic node immediately and view the relationships it shares with other topic nodes. The Viewer also keeps a history of visited topic nodes so that users can backtrack easily. The history is also visualized in the History View as a graph that will show any diverging paths that the user has taken.

4.3 The Administrator

The purpose of the Administrator application is to allow users to enter domain-dependent information

as addendum to the domain-independent information discovered by the crawler. The user can modify any topic or association using the application.

Bloom's diagrams can be built using the Graphic Organizer Wizards provided by the application. The wizards allow users to easily add more semantics and relations to the crawler-produced topics. Each type of diagram created using the wizards will be colour-coded in the Viewer so it would be easy for users of the Viewer to identify the types.

The Administrator application can also act as a simple graphic organizer builder. Users can start a new domain and add topics and associations manually or with the wizards. This is useful if the user just wanted to use a few pages to create a meaningful diagram, and did not need the entire Wiki to be crawled.

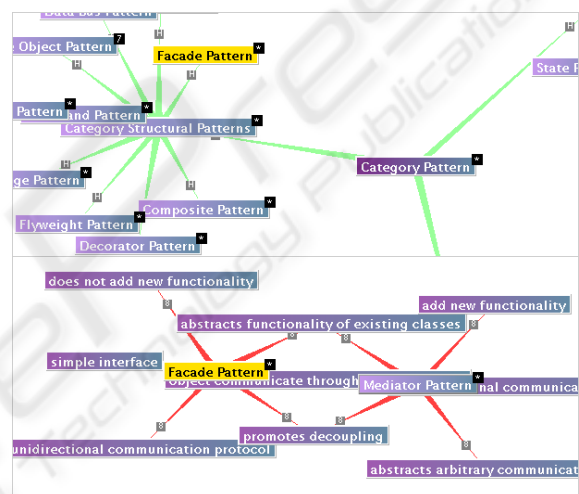


Figure 3: Isolating the hierarchy diagram (top) and double cell diagram (bottom) using filters help users see different information about Facade pattern.

5 EVALUATION

5.1 Experimental Design

To evaluate ENWiC, we carried out an experiment that tested its usability against a standard Wiki. We set up two conditions: the control condition, where the subject uses a standard Wiki to answer questions; and the experimental condition, where the subject uses ENWiC to answer questions. Half of the subjects will switch from control condition to experimental condition, and vice versa for the other half. The subjects are computing science students, and so we choose design patterns as the subject domain for our tasks. We selected the Portland Pattern Repository's Wiki (<http://c2.com/cgi/wiki>) for this experiment since its content concentrates on software development, and we used ENWiC to

crawl a mirror of the Wiki to create the topic map. We also used the Administrator wizards to put in hierarchy diagrams, double cell diagrams and comparison matrices to add some domain-dependent relations and keywords that the Crawler did not pick up in the pages.

Table 1: The experiment tasks.

| | |
|-----------------------|---|
| e a s y | Give an example of how credit card service can use the Strategy pattern. |
| | Consider a chat room application. What is the subject and what are the observers? |
| d i f f | What is the class of design pattern that Decorator belongs to? What is the class of design pattern that Memento belongs to? |
| | List two patterns that promote decoupling by using a central object for communication. |
| i c u l t | Consider a pager service. Why is the façade pattern inadequate for this scenario? Which pattern would be more suitable? |
| | You would like to make a deposit to your personal accounts at the bank. The bank has a group of tellers; you are called to the teller that can handle deposit to personal accounts, who will process your request. What pattern does this resemble? |

After giving them a short tutorial on Wiki and ENWiC, the subjects answered a total of six questions: three using ENWiC and three using the Wiki. Each set of three contained one easy question that involves only one design pattern and two questions that required subjects to combine information from different patterns. The subjects have a maximum of 15 minutes to answer each question.

During the experiment, we observed the subjects and we recorded the time to completion, the number of unique nodes/pages visited, the number of mouse clicks on ENWiC nodes and the number of link traversals and back-button clicks on Wiki. After they completed their tasks, we asked our subjects to fill out a questionnaire about the usability of the two applications, and their overall impression and experience with the two applications.

Finally, we evaluated the correctness and the completeness of their answers.

5.2 Results and Observations

We found that time-to-completion was not an adequate measurement since it depended more on the subject than the condition. Generally, completion times were shorter with ENWiC, but some subjects took more time than others regardless of the conditions. Also, subjects took less time to answer later questions since they remembered information from the first few questions and had a better idea of where to look. On average, completion time for a task in ENWiC is 3:17 minutes, while in Wiki it is 3:31 minutes. Since ENWiC's loading time per page

is quite longer than Wiki, the completion times for ENWiC could potentially be even better.

For a better measure, we examined the number of unique pages/nodes visited and the number of clicks. As shown in Table 2, we noticed our subjects used significantly less number of clicks to complete the hard questions when using ENWiC. This was not significant with the easy questions where the answers were on a single page, but on the hard questions, subjects were able to move to desired pages just by using the graph, as opposed to having to click on the Back button many times while using a traditional browser.

Table 2: The number of clicks and unique pages/nodes visited for each subject (A-F) for each question (1-6).

| | 1 | 2 | 3 | 4 | 5 | 6 |
|----------|---------|---------|----------------|-----------|-----------|-----------|
| A | 5,E:3,2 | 2,W:5,5 | 1,W:8,6 | 4,E:1,1 | 6,E:7,3 | 3,W:43,26 |
| C | 2,W:4,2 | 5,E:3,3 | 4,E:5,3 | 1,W:40,14 | 3,W:33,17 | 6,E:3,2 |
| E | 2,W:2,2 | 5,E:3,3 | 4,E:4,4 | 1,W:24,7 | 3,W:9,4 | 6,E:2,2 |
| B | 5,W:4,3 | 2,E:1,1 | 1,E:8,7 | 4,W:19,16 | 6,W:29,18 | 3,E:6,6 |
| D | 2,E:3,3 | 5,W:2,2 | 4,W:10,6 | 1,E:3,3 | 3,E:3,3 | 6,W:9,7 |
| F | 2,E:4,3 | 5,W:2,2 | 4,W:2,2 | 1,E:13,8 | 3,E:4,4 | 6,W:2,2 |

Each cell (formatted as O,W/E:C,P) reports the order in which the question was asked (O), the tool in which it was answered (E for ENWiC and W for Wiki), the number of clicks involved (C) and the number of unique nodes/pages (P) visited. The first three subjects in the table used Wiki first and then switched to ENWiC, while the other three subjects used ENWiC first before using Wiki. The crossed-out values indicated that the subject was timed-out before he could finish the task.

The numbers for the easy questions (1 & 2) were similar for both tools, but for the harder questions, it can be seen that the number of pages/nodes the subjects used in Wiki is more than ENWiC except in one case (outlined in bold), where that particular subject knew which pages to look. In terms of the number of clicks, the margin between ENWiC and Wiki is even higher, indicating that the subjects went through significantly less irrelevant information and pages when using ENWiC.

According to our observations, reading times were also reduced in some cases, especially when the subjects had to seek out certain relationships, as it was faster to look at the links on the graph than to read the text to find the information. Also, subjects using Wiki may overlook links to potentially better pages; for example, when answering question (1) from Table 1, the Wiki page that described Strategy pattern contains a link to another page that has an example of Strategy pattern. On ENWiC, that link has a section node "Example" associated with it, and thus ENWiC users easily recognized that link as a

useful; it took Wiki users longer to realize that, and in some case they did not visit the link at all.

ENWiC was able to give the area of where solutions may be located. For example, when subjects answered questions (4) or (5) from Table 1, when they search and locate the Façade pattern, they identified the Mediator pattern as the most likely solution for the second part of the question since it appeared in the graph near the Façade pattern node, while it was not as obvious for the Wiki users. When a subject misses such relationship, they have to go through more patterns to finally identify the Mediator pattern. Thus, ENWiC helps reduce the number of unique pages that a user has to read since it can limit the area of pages that user has to look through.

We carried out a statistical hypothesis testing based on our data. For each question, we examined whether the number of clicks and the number of pages visited for each task was smaller when using ENWiC than when using the standard Wiki interface. Thus, we state our hypotheses as:

$$H_0 : \mu_{\text{Wiki}} = \mu_{\text{ENWiC}} \text{ (Null Hypothesis)} \quad [\text{Eq.1}]$$

$$H_1 : \mu_{\text{Wiki}} > \mu_{\text{ENWiC}} \text{ (Alternate Hypothesis)} \quad [\text{Eq.2}]$$

$$\text{Selected significance level: } t_{0.05,4} = 2.132 \quad [\text{Eq.3}]$$

We used T-statistics for our hypothesis testing. The results are summarized in Table 3.

Table 3 shows that there was a significant decrease in the number of clicks and number of visited pages when using ENWiC for questions 4 and 5. These were difficult questions, in that to answer them the subjects had to combine information from more than one wiki pages. Question 3, although it was also difficult, did not have a significant difference because some subjects were able to utilize the Wiki Category page to answer the question. Question 6, again difficult, did not have a significant difference because some subjects remembered some information while looking for solutions to previous questions. They were able to identify which pattern is the most likely candidate for the solution, thus reducing the number of pages and clicks they used while working on this question.

Table 3: Results for our hypothesis testing for each individual question. The values marked with * are significant enough to reject the null hypothesis (Eq.1).

| Question | T _o (# of clicks) | T _o (# of pages) |
|----------|------------------------------|-----------------------------|
| 1 | 0 | -0.707 |
| 2 | 0.555 | 0.5547 |
| 3 | 0.372 | 0 |
| 4 | 2.997* | 2.428* |
| 5 | 2.526* | 2.138* |
| 6 | 1.127 | 1.121 |

We also carried out a similar hypothesis testing for the number of clicks and pages needed to complete all tasks. We believe that the number of pages and the number of clicks needed to complete all tasks in Wiki is more than in ENWiC. We state our hypotheses as:

$$H_0 : \mu_{\text{Wiki}} = \mu_{\text{ENWiC}} \text{ (Null Hypothesis)} \quad [\text{Eq.4}]$$

$$H_1 : \mu_{\text{Wiki}} > \mu_{\text{ENWiC}} \text{ (Alternate Hypothesis)} \quad [\text{Eq.5}]$$

$$\text{Selected significance level: } t_{0.05,34} = 2.032 \quad [\text{Eq.6}]$$

The results for the above hypothesis testing are summarized in Table 4.

Table 4: Results for our hypothesis testing for all tasks. The values marked with * are significant enough to reject the null hypothesis (Eq.4).

| Question | T _o (# of clicks) | T _o (# of pages) |
|----------|------------------------------|-----------------------------|
| 1-6 | 2.611* | 1.790 |

The results in Table 4 validate our observations that subjects generally use less number of clicks when using ENWiC instead of Wiki. The shorter completion times and the lower number of clicks in ENWiC agree with the cognitive theory, which suggested that textual presentations cause more memory stress than visual presentations. Since it was easier for subjects to remember their location with ENWiC, they could complete tasks with shorter times and paths.

Correctness and completeness of the tasks were not significantly different between the two tools, which were expected because ENWiC gets its data from the Wiki, so once subjects locate the proper information, they usually arrive at the same conclusion. ENWiC just helps subjects to identify the proper data faster.

Since ENWiC does differ from conventional browsers, we found that subjects needed some time to learn and adjust to the interface. Some subjects learned quickly and were able to utilize the tool very well, while some had difficulties adjusting and learning how to read the graph and utilize the diagram filters. We found that subjects who like to use index and category pages from the Wiki were better at interpreting the graph of ENWiC, while subjects who use the search function or prefer to read text may not adjust as well to the graph. Since the search functions in the Wiki and in ENWiC were not as sophisticated as search engines like <http://www.google.com>, the answers cannot be directly obtained using the Wiki or ENWiC search. Some subjects did appreciate that the ENWiC search function can narrow down the area of where the solution may be, but the few subjects who did not utilize the graph did not find ENWiC a lot more useful than Wiki.

Based on the questionnaires, almost all subjects found ENWiC to be an interesting tool to use. The main advantages they outlined were: relationships

between topics can be seen clearly, which allows for easier navigation; they did not feel as lost when searching for answers; and they can select and traverse the relevant path faster.

The one disadvantage of ENWiC that all subjects agreed upon is its speed. Since the ENWiC viewer has to render a graph while loading a page, the display of it takes more time as compared to the standard Wiki interface. Subjects who are used to moving and reading pages quickly found the speed of ENWiC an annoyance that deteriorates satisfaction.

Multiple intelligence (Gardner 1983) suggested that there are eight different types of intelligence, which implies that there may be eight different styles of learning depending on the individual. Two of the eight types of intelligence are: linguistic (words) and spatial (visual). From our experiment, it is evident that ENWiC is useful for subjects who could interpret graphs and visuals better, as ENWiC is targeted for spatial learning, while subjects who learn with words (linguistic intelligence) may or may not find ENWiC better than a standard Wiki. Subjects who could adapt to both types of learning style liked ENWiC because it was different than conventional text navigation, which made it more interesting and enjoyable to use.

6 CONCLUSIONS

E-Learning is fast becoming the mode of choice for delivering courseware in educational institutions. Wikis are on-line knowledge bases, built collaboratively by communities of people studying or having an interest in a particular domain. As such they are frequently used in support of teaching and learning.

ENWiC offers an alternative user interface to the standard text interface of Wikis. Its graphical representation of a Wiki helps users to see an overview 'map' of the Wiki, which enables efficient navigation. It is highly beneficial for users who are visual learners and like to see the relationships between topics, and its stimulating interface can capture users' interest to encourage them to learn. Since the creation process is mainly automated by a crawler, it is also easy for authoritative experts to use ENWiC as an instructional tool.

Our usability study indicates that ENWiC supports shorter times for accomplishing tasks based on wiki information. Through its visualization of the domain, ENWiC makes visible the wiki navigation structure, which is beneficial to self-learning. Its usage is not limited to Wikis only, as its design can be easily applied large scale websites, such as

blogs or online journals, which will help expand content that can be effectively used for e-Learning.

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