

AnnotatEd: A Social Navigation and Annotation Service for Web-based Educational Resources

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Abstract: The World Wide Web is currently the single most popular hypertext system; however, a number of features that were common for advanced “standalone” hypertext systems are not supported by the web. These features are important for such demanding application areas as education. To answer this need, a range of projects focused on enhancing the web. The most active thread of work is content annotation. Other threads focus on enhancing web hypertext with advanced hypertext tools, including guided tours and adaptive navigation support. Existing projects enhance web hypertext with only one method. The project presented in this paper attempted to integrate annotation and adaptive navigation support into a single value-added service for accessing web-based educational resources. The AnnotatEd system that we have developed offers both and adaptive navigation support (through social navigation). The paper also reports our attempts to evaluate the AnnotatEd system.

Introduction

The World Wide Web is currently the single most popular hypertext system; however, it is far from being the most powerful or the most advanced hypertext system. A number of features that were common for advanced “standalone” hypertext systems are not supported by the web. However, these features are important for such demanding application areas as education. To answer this need, a range of projects focused on enhancing the web with traditional functionalities of advanced hypertext systems. The most active thread of work is content annotation. A number of advanced hypertext systems have supported annotation in the form of highlighting or underlining a part of the text, or associating free format or structured comments with a portion of a page. The ability to annotate is important, but it is not inherent to web architecture. To compensate for the missing functionality, many web-based hypertext systems have offered proprietary approaches that will annotate their closed corpus content. The ability to annotate non-restricted web content (open corpus) was originally supported on the client side by some early browsers, but later became a function of a range of web annotation systems that give value-added services and store annotation on the server side. This move was originally caused by browser problems, but later fueled by the extra value provided by centrally storing annotations: the ability to share annotations with others (Gibeo 2006, Xin & Glass 2005). This ability enables open and closed corpus web annotation tools to support collaborative work over the web.

Other threads of work based on enhancing web hypertext with advanced hypertext tools include guided tours and adaptive navigation support. Guided tours allow a user to navigate a complex hyperspace along a linear, predefined path which has frequently been augmented with a guiding narration. This functionality was implemented in many closed corpus web hypertext systems and also supported for the open corpus web by both browser-side support (Moody 1998, Noda et al 2004) and intermediary-style systems such as (Sandvad et al 2001, Shipman et al 2000). Adaptive navigation support helps the user to select the most relevant links to navigate. It has been implemented in many closed corpus adaptive hypermedia systems (Brusilovsky 2001).

One of the problems of the research on enhancing web browsing with advanced hypertext functionality is how to support several functionalities in one system. While each enhancement offer some added value, existing projects focus on advancing web hypertext in only one direction – whether it is annotation, guided tours, or navigation support. The most interesting research question is how to integrate two or more of these enhancements so that the result will be more than the sum of its parts. For example, the integration of annotation and guided tours could enhance the value of narration in educational context by including author- and user-created narration.

This paper presents our attempt to integrate annotation and adaptive navigation support for open corpus web educational resources into a single value-added service. The AnnotatEd system that we have developed offers both annotation (through highlighting and free-text comments) and adaptive navigation support (through social navigation). It works in the traditional intermediary way, by standing between a web page and its user. Each web page is pre-processed by AnnotatEd before being displayed to the user. During this pre-processing stage, AnnotatEd adds adaptive visual cues to all eligible links and generates an additional annotation frame that allows the user to view and provide annotation. The navigation support and annotation components in AnnotatEd each enhance the other one's value. The navigation support component makes user annotations more visible and valuable by adding visual cues to all links that lead to pages previously annotated by the user. In turn, access to annotations written by multiple users on the same pages allows the social navigation support component to extend the traditional traffic-based support with annotation-based support.

The rest of the paper is organized as follows: sections 2 and 3 review related work in the area of web annotation and social navigation. Section 4 describes AnnotatEd system and different phases of the development of the system. Section 5 reports our attempts to evaluate the system and the ideas behind the system. Section 6 concludes the paper and describes some future directions for the work.

Web Annotation

The growing number of web annotation tools can be classified in two groups. The annotation systems of the first group focus on developing an advanced architecture and building a more sophisticated but simple-to-use annotation interface to improve web-based annotations. They try to support content-aware annotation on any arbitrary web page. Gibeo (Gibeo 2006) is an example of a well-designed web annotation system. Once the user is registered with their website, in order to annotate any random web page, the user merely needs to add “.gibeo.net” to the URL. When any part of the text on the page is highlighted, a set of options is displayed to allow the user to specify whether the highlighted text is “important”, “wrong”, or “cool”. The users can also add comments, corrections, links, or shared discussion to any part of the text. All the annotation is shared with all users of the system and clicking on the annotation provides detailed information about the annotation, such as the author of the annotation. Marginalia (Xin & Glass 2005) is a javascript web annotation system that focuses on providing intuitive annotation functionality for any arbitrary web page as well as the Moodle discussion forum. Marginalia allows users to highlight any part of the text and write associated comments in the margin of the pages. Annotation may be marked as public or private.

The annotation tools of the second group use annotation for collaboration over the web. The most famous tool in this group is Annotea, which enhances the collaborative development of the Semantic Web via shared web annotations. Annotations are in the form of comments, notes, explanations, or any other type of external remarks attached to any web document or portion of the document. The users are able to access all attached annotations when they open the original document (Koivunen 2005). Another popular tool is a “web discussion” feature in Microsoft Office 2000 that allows collaborative annotation of any web page. (Cadiz et al 2000) studied the application of this annotation tool to collaborative writing for a large product group at Microsoft and reported quite a variation in the usage of these annotations.

Social Navigation Support

Classic adaptive navigation support techniques (Brusilovsky 2001) are well-known tools for guiding learners to the appropriate resources. However, since these techniques rely on manual annotation of the content by experts, they are not well suited for the large volume of open corpus documents. Social navigation support (SNS) techniques are based on social navigation theory (Dourish & Chalmers 1994). Dourish and Chalmers define social navigation in information space as “moving towards cluster of people” or “selecting subjects because others have been examining them.” SNS technique makes use of past learners’ interactions with the system to guide new users of the system and relies on the *collective knowledge* of a large community of users. AnnotatEd, the system that we present in this paper provides two types of SNS: traffic-based and annotation-based. *Traffic-based* SNS relies on the traditional footprints concept in social navigation (Wexelblat & Mayes 1999). It generally provides information about the number of visits users have made to each link. Traffic-based SNS promotes links, which have a higher number of visits. For example, Dieberger and Lonnqvist (2000) modified the collaborative web known as the CoWeb to visualize traffic-based social navigation. The system tracks how often a page is accessed or modified. It visualizes the density of the aggregated access for the past 24 hours by applying three levels of color intensity to the

footprint symbol. *Annotation-based* SNS provide stronger support by employing the annotation activities of the users instead of counting visitors (ref. removed). These systems promote links to pages annotated by users, especially pages with higher numbers of annotations or positive annotations. For example, Educo (Kurhila et al 2002) provides an annotation tool which allows learners to associate comments with a document. It provides simple annotation-based SNS by keeping track of when comments are modified and visually demarcates new comments.

AnnotatEd

AnnotatEd (Annotations for Education) provides social navigation and annotation services for browsing collections of linked web educational resources. AnnotatEd was originally implemented to support Knowledge Sea system (ref. removed). Knowledge Sea is designed to help students navigate from weekly lectures to relevant online educational materials, in a map-based, horizontal navigation format. AnnotatEd enables Knowledge Sea to provide annotation and traffic-based SNS. However, AnnotatEd is independent of Knowledge Sea system and can be used with any linked collection of web resources. AnnotatEd accompanies the learners from page to page by redirecting all the links inside the page through the AnnotatEd server.

AnnotatEd allows students to annotate web pages by placing free-format comments that will be associated with the whole page or by highlighting specific parts of the page. In addition to allowing learners to annotate web pages, AnnotatEd also annotates links inside the pages in order to offer social navigation support. Navigation support is provided in the form of social navigation—annotating the link after measuring the past activity of the group. In addition to indicating group activity, link annotations also indicate individual activity of the user. Each link inside the page is annotated with two different icons shown in Figure 1.



Figure 1 – Navigational Cues

The Traffic icon represents traffic-based SNS. The background color represents the magnitude of visiting activity done by the group of users. A darker color represents a higher number of visits. The human figure represents individual visiting activity. The human icon is presented with different shades of blue and the density of the color represents the magnitude of the individual's visits. The details of how the color is computed can be found in (ref. removed). The *annotation* icon represents annotation-based SNS. Similar to the *traffic* icon, the background color represents the magnitude of group annotation activity and the color of the sticky note icon represents the magnitude of individual annotation activity.

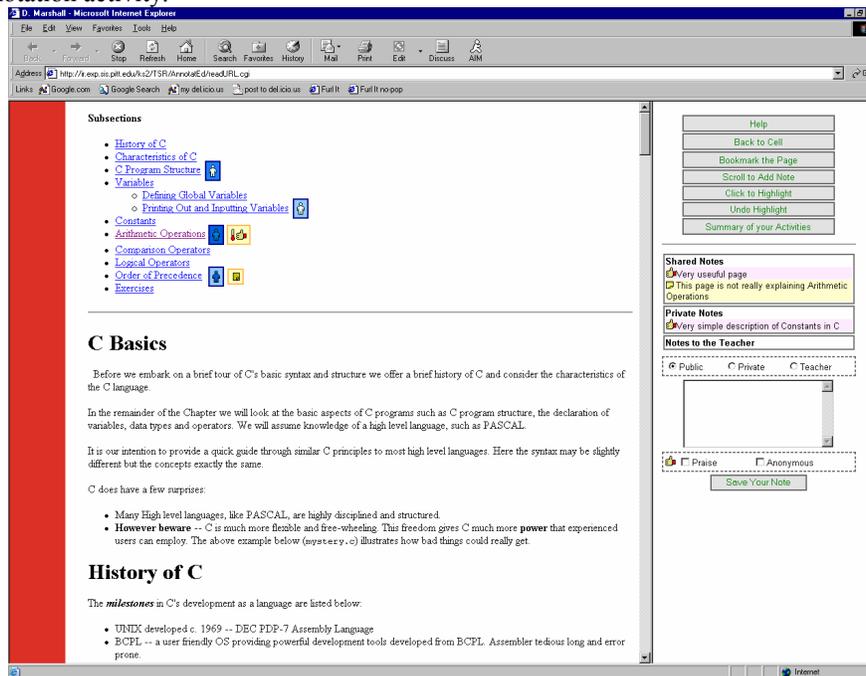


Figure 2 - Link annotation inside AnnotatEd

To offer social navigation support, AnnotatEd keeps track of all activities of the users: every click they make, the time they spend reading each page, and every annotation they make for each page. Figure 2 shows a page viewed through AnnotatEd where links are annotated with *traffic* and *annotation* icons.

4.1. Baseline Implementation

AnnotatEd began with a very simple annotation interface accompanied by a complete tracking feature. The first version provided an easy-to-use interface for annotating educational resources by letting students add comments to the page. Students were not able to share notes with others and were not aware of which pages were annotated by others. AnnotatEd was tracking all visiting activities and links inside the pages were annotated with individual and group traffic-based SNS. Also, the links to pages with user annotation were enhanced for the author of each annotation.

Our preliminary evaluation of annotations showed that about 60% of the students appreciated the ability to annotate and further, were interested in sharing their annotations, seeing annotations made by others, and knowing which pages were annotated. In addition, we examined notes written by the students and discovered that almost all notes could be categorized into three groups: praise (a positive point about the page), problem (a negative point about the page), or general (a neutral statement such as “I have to go back to this page”). Considering this classification, 37 notes could be classified as praise, 36 as problem, and 34 as general. This data motivated us to proceed with expanding the user's annotation ability and exploring the use of annotation as a source of more reliable SNS. In the early stages of the expansion of AnnotatEd, we added the ability to make public and private annotations and to choose one of the above three categories for annotations (praise, problem, or general note). In this phase, the students were able to view notes written by others and links to pages with public annotations were augmented with the annotation icon (Figure 1).

Phase II

Figure 3 presents the annotation interface of AnnotatEd in Phase II. As shown in the figure, the top part of the annotation interface displays previously written notes. The previously written notes can be classified into three categories: shared (public) notes written by others, shared notes written by the current user, and private notes of the current user. Shared notes and private notes are presented in two different boxes. Shared notes written by the current students and others are distinguished by the background color. Shared notes written by the current student have a pink background and shared notes written by others have a yellow background. Both shared and private notes are ordered chronologically, so that the most recent ones will appear on top. An icon which represents note category is added to the notes. A thumbs up-icon represents positive notes, a question mark icon represents problem type notes, and a sticky note is used for general notes.

Our evaluation of the early stages motivated us to introduce several new features in the second stage. To allow for a simpler form of annotation, we added highlighting. To highlight, one can just select any part of the text and click on the “highlight” button. Highlighting creates an effect similar to that of using a highlighter on paper. In this phase, we also added the option to author non-anonymous notes. The students can choose to sign notes with their name or keep them anonymous. We added this option in order to motivate students to share feedback with their classmates. At the end of this phase, we observed that in fact 90% of the annotations (46 out of 51) were signed, even though anonymous annotation was the default.

We also tried to offer stronger navigation support by visualizing annotation *temperature* and by using the annotation *type*, which had been provided by the student author. The Annotation icon used to augment the links inside the pages was modified to represent this information. The background color of the square represented the same information about the density of group annotations. But, the sticky note icon inside the square was replaced by a thumbs-up icon to indicate a positive annotation from the logged-on user, or a question mark to indicate a problem type note from the logged-on user. We used the same sticky note to indicate the existence of a general note. Similar to the previous phase, the color of the foreground icons represented the density of individual notes. In addition, a thermometer icon was added to present the “temperature” of the annotations of the group of the students. The temperature grew warmer when a page attracted more positive annotations and colder when it attracted more problem-type annotations.

Phase III

The evaluation of the second phase made us aware of some interface problems. After an analysis of students' annotations we discovered that the difference between types of annotation was not very clear to the students. First of all, many obviously positive annotations were categorized by the students as being merely "general" notes. 61% of the "general" annotations were really "praise." We hypothesized that the interface could have triggered this problem. As shown in Figure 3, in order to write a note, students must first choose the type, then choose the privacy level and authorship, then write the note, and click to save the note. The default type is set to general and changing the type from default to any other case is optional. We assume that the box for selection of type was too distant from the saving note button, so that the students could easily forget to choose the type. Secondly, "problem" annotations were used not to indicate a negative page (as we had assumed), but to report problems with the page to the teacher. As a result, in the current interface (developed in Phase III) we removed the problem type and added an option to write a note that would only be seen by the instructor of the course. The note to the instructor could serve as a way to report problems within the educational material. We also rearranged the interface so that the options were closer to the "save note" button. In this phase we also added a book-marking feature to let students bookmark important pages. They would also be able to view a report about the annotated or bookmarked pages. They were able to choose specific time frames and view the list of pages bookmarked or annotated in the chosen time frame. The time frame is the current session by default and can be chosen as the whole semester as well. Figure 4 presents the current interface of AnnotatEd.

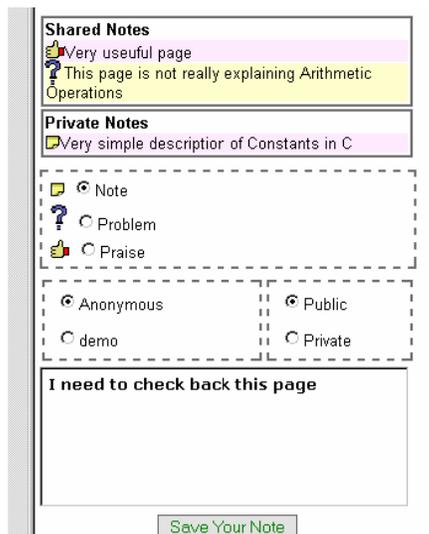


Figure 3 – The Annotation Interface (Phase II)

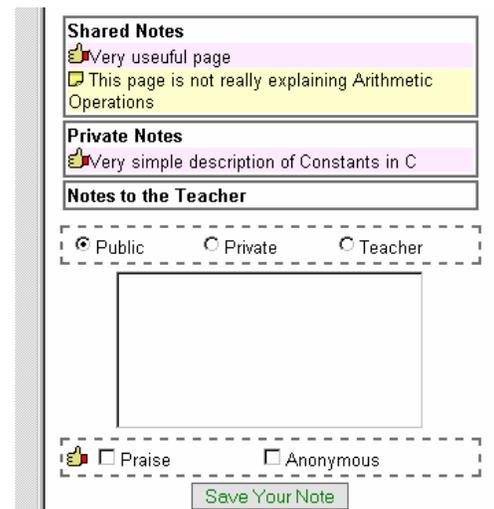


Figure 4 – The current AnnotatEd interface

Evaluation

AnnotatEd has been used in (ref. removed) for about 5 semesters and has been evaluated at the end of each semester. This paper focuses on evaluation of the recent developments. The recent evaluation includes two semesters of classroom studies. The studies were done in an introductory C programming course (undergraduate), and Information Retrieval course (graduate) taught by the same instructor. In both classes, 12 students used the system throughout the semester to access useful educational content related to their course. The system was introduced in the class by the instructor and students were able to access the system anytime, anywhere. During the study, all the students' interactions with the system were logged for log analysis. We also conducted a questionnaire at the end of the semester, to collect the students' subjective comments. The following is a list of the hypotheses we hoped to evaluate:

1. Providing navigation support for browsing collections of web educational resources is important, because browsing-based access is popular among students even with presence of other access options such as search and map-based navigation.
2. Annotating links with SNS cues would affect the students' decision of which link to follow.
3. Pages with annotation-based SNS are important pages.

4. Students would appreciate the annotation functionality of the system.
5. Students would appreciate the annotation-based SNS inside web pages.

Browsing versus Map-based Navigation and Searching

As mentioned before, AnnotatEd is connected to Knowledge Sea, which is a navigation map. The whole system also offers a search interface. Therefore, the same educational materials can be accessed in different ways. Also, the same navigation support is provided for all three access methods (map, search, browsing). To evaluate our first hypothesis, we compared usage of these three accessing methods by tracking the source of each web page access. Although map-based navigation is known to be advantageous, as it can be seen in figure 5, the overall number of accesses done through browsing was higher than the number of map-based accesses. Also, while searching is the most available navigation method on the web, our results show that the lowest number of accesses were done through searching. It is worth noticing that the usage of search in the information retrieval course was significantly higher than in the C programming course. This may be related to the fact that information retrieval students are graduate students. Being more advanced in the field and more familiar with web searching is an advantage; however, we observe that independent of the level of students' expertise, browsing is important. Over both semesters about 50% of the accesses were done through browsing. The results support our first hypothesis and present the importance of supporting browsing as a method to access web educational resources.

We also hypothesized that pages selected through browsing would be more interesting to the students, since they have more contexts from which to choose the page and they are more certain about the content of the page. To assess our hypothesis, we looked at the exact pages accessed from two different accessing methods: map and browsing. We found 62 pages accessed by both map-navigation and browsing. We measured the desirability of the page by the time the student spent on the page, since time spent has been proven to show a strong correlation to interest. We observed that students spent significantly more time on a page when they accessed it through browsing: the average visit time for the page accessed through browsing is 103.84 sec. vs. 64.26 sec. for access through the map (p-value is 0.028 on a paired t-test).

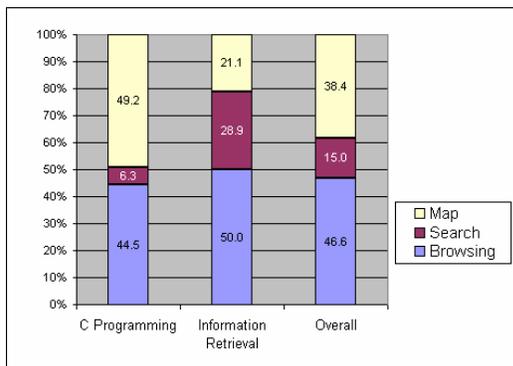


Figure 5 - Percentage of access from each method

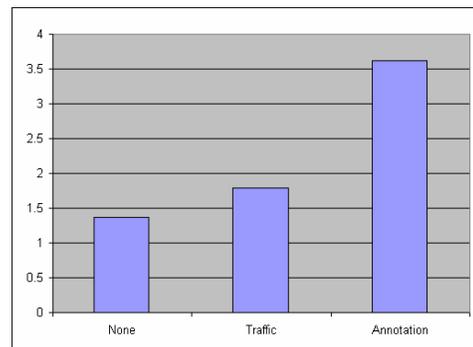


Figure 6 - Average number of clicks for pages with and without traffic/annotation based SNS

The Effect of Social Navigation Support on Link-Following

To evaluate the effect of annotating links with SNS cues, we compared the number of accesses to links with and without traffic-based or annotation-based SNS cues. As can be seen in figure 6, pages with traffic- or annotation-based SNS attracted a higher number of visits, with annotation-based SNS pages attracting the most visits. In both cases, the difference is significant ($\alpha = 0.95$). The results support our second hypothesis and suggest that annotation can play an important role in providing navigation support to users.

Importance of Pages with Student Annotation

Our results show that students are more likely to follow a link to a page that has peer annotation on it; therefore, it is essential to know whether this guidance is accurate, by assessing the quality of these pages. To evaluate the quality of annotated pages, we calculated the average access to the page before the page was annotated, to subtract out the effect of student annotation. We compared this to the number of average accesses to pages with no annotation. In both semesters, as shown in Table 1, pages with student annotations had attracted significantly more

clicks even before being annotated. This result suggests that annotated pages are important, which supports our third hypothesis. Thus, annotation-based SNS is, indeed, guides the students to important pages.

Table 1 - Average access to pages with and without annotation, before the occurrence of first annotation

	Annotated	Not Annotated	p-value (<i>t</i> test)
C programming	3.15	2.02	0.03
Information Retrieval	2.58	1.42	0.0005

Subjective Data Analysis

To evaluate our 4th hypothesis, we asked students about the usefulness of the annotation functionality of the system. In the C programming course we asked separate questions about writing note functionality and highlighting functionality, while in the information retrieval course we asked one general question about annotation functionality, in order to decrease the number of questions asked. As shown in figure 7, more than 80% of students in all cases appreciated annotation functionality of the system. The result supports our 4th hypothesis.

To evaluate student opinion about annotation-based SNS, we asked 1) about the usefulness of providing the magnitude of public annotations, 2) whether there should be a private annotation type, and 3) whether the overall temperature of a link influenced them to follow a link. The questions were multiple-choice asking the level of agreement with the statement in the question. The questions were exactly the same for both courses. As presented in figure 8, all but one case agreed with the usefulness of annotation-based SNS and a significantly large percentage of the students appreciated annotation-based SNS.

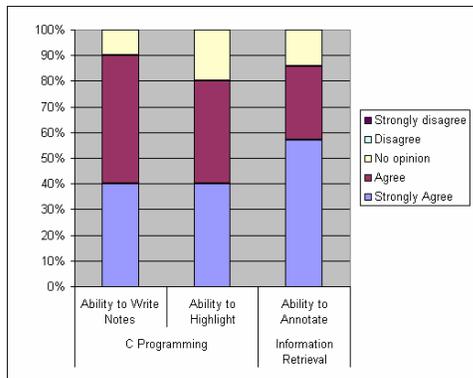


Figure 7 - Student attitude towards the annotation functionality of the system

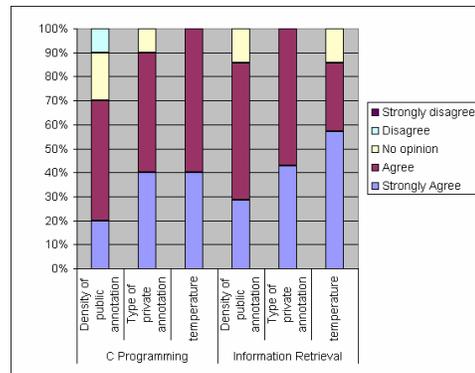


Figure 8 - Students' attitude towards annotation-based SNS inside web pages

Conclusion and Future Work

AnnotatEd provides social navigation service as well as the ability for students to add annotations when browsing educational resources on the web. AnnotatEd keeps track of visitor actions and the annotation behavior of students and uses this information to offer social navigation support. Social navigation support is offered through the adaptive annotation of links inside web pages. We evaluated the importance of providing the browsing option in addition to structured navigation options, such as map-based navigation or search-based navigation. Our results show that browsing is used by the students at least as frequently as map-based navigation, and is more frequently than searching. Also, as a context-rich method of information access, browsing provides better support to the students in selecting relevant links. These data helped us to justify the investment into providing social navigation support for browsing collections of web educational resources. It is technically harder to implement social navigation support in browsing context, where real open corpus pages have to be augmented with annotations, than in map or search context where no changes of real pages are required. However, this technical challenge is worth to fight due to the value of browsing-based access. We also evaluated the effect of traffic- and annotation-based SNS on students' decision making. Our results show that students access augmented links significantly more frequently. Moreover, we assessed the importance of pages that have been annotated by students. The results suggest that pages with student annotations are more attractive to students. This data shows that SNS is not only worthy to provide but that it

actually works guiding the students to relevant quality educational resources. The subjective data analysis also presents a highly positive student attitude towards the annotation functionality of the system and annotation-based SNS.

While evaluation with a higher number of users remains as the most important goal of our future work, we would also like to improve our annotation interface by enabling pen-based annotation. We hypothesize that a more advanced annotation interface will encourage students to annotate more. Also, the bookmarking feature of the system is very primitive and we have not yet provided any navigation support based on pages bookmarked by students. Our bookmarking feature is very similar to the general one supported by all browsers and thus we did not observe a high usage of bookmarking in the current version. We would like to add bookmarking information to our adaptive social navigation support in the next version of the system.

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