# Social Navigation Support through Annotation-Based Group Modeling

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**Abstract.** Closed corpus AH systems demonstrate what is possible to achieve with adaptive hypermedia technologies; however they are impractical for dealing with the large volume of open corpus resources. Our Knowledge Sea project explores social navigation support, an approach for providing open corpus personalized guidance that is based on past learners' interaction with the system. This paper presents the most recent stage of our project that focuses on using annotations for social navigation support. We present most recent version of Knowledge Sea that implements annotation-based social navigation support and reports the results of several classroom studies evaluating this technology.

## 1 Introduction

Day by day the amount of information on the Internet grows which makes Internet an important resource in learning. However, learners are having hard time finding what they are looking for and are very often frustrated with the searching process. It is known that adaptive navigation support techniques developed in the field of Adaptive Hypermedia [1] could guide learners to the right resources at the right time. However, concept-based navigation support mechanisms used in traditional Adaptive Hypermedia (AH) systems are not suitable for large volume of open corpus documents. In search for a mechanism for adaptive navigation support in open corpus hypermedia, we turned to the ideas of social navigation [5]. We have attempted to develop personalized navigation support techniques that are based on past learners' interaction with the system. We call this *social navigation support* (SNS). Unlike traditional adaptive navigation support that relies on expert-provided knowledge about each resource, *social* adaptive navigation support relies on the *collective knowledge* of a large community of learners gathered through different forms of feedback.

We explored social navigation support in the context of Knowledge Sea project that currently focuses on helping students of introductory programming courses find relevant readings among hundreds of online tutorial pages distributed over the Web. On the first

stage of our project we have explored relatively straightforward "footprint" techniques suggested in early papers on social navigation [4; 8]. The idea of the "footprints" is counting how many users are passing through a link or visiting a page and recommending most popular links and pages. Combining the ideas of social navigation with the ideas of group modeling and adaptive navigation support, we have implemented the first version of "socially adaptive" Knowledge Sea II system [2]. The system used adaptive annotation with blue color of variable intensity to indicate how many users of the same group have visited each tutorial page and each cluster of tutorial pages: the more visits, the more intensive was the color (**Fig. 1**~~**Fig. 1**~~). This kind of SNS helped the learners to clearly recognize most and least visited pages and make their navigation choices appropriately. Our classroom study [2] has demonstrated that footprint-based SNS is able to increase the usage of open corpus resources and that the learners appreciate it a lot. At the same time, a few students pointed out that the number of visits to a page is not always a reliable measure of its relevance to their needs and asked for better relevance indicators.

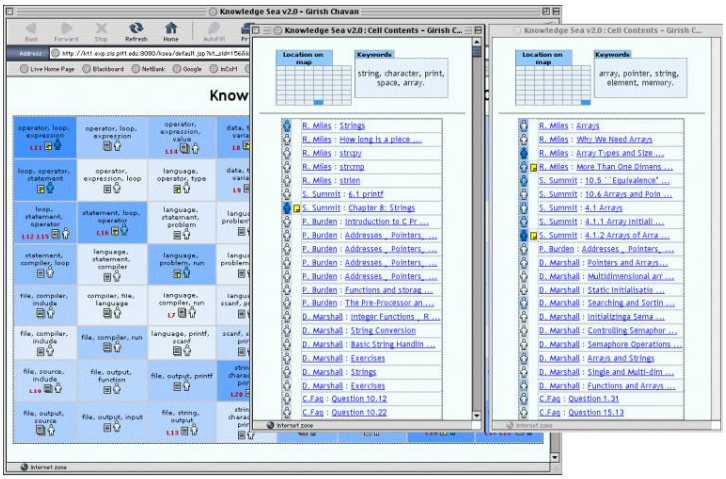


**Fig. 1**. - The map view and two cell views in Knowledge Sea II

The paper presents the second stage of our project that focused on providing more reliable SNS through collecting learners' feedback and using it for prediction of other learners' interest in the resource. Our main challenge was to extract feedback from actions that users are naturally performing while working with the system. To answer this challenge we explored annotation-based social navigation support. We encouraged learners to annotate pages they are reading in the form of writing notes or highlighting part of the page they found important. These annotations were used as an implicit indicator of page relevance for a specific group of learners. The annotation-based SNS was implemented in the new version of the Knowledge Sea (KS) and explored in two classroom studies. The results indicate that it is a promising approach for open corpus

adaptive navigation support. In the following sections we introduce our system Knowledge Sea, describe two consecutive implementations of annotation-based SNS, present the results of the classroom studies, and analyses similar projects.

## 2 Annotation-based Social Navigation Support in Knowledge Sea

The starting point for our work on annotation-based SNS was the Knowledge Sea II system. The Knowledge Sea II interface shown on Fig. 1~~Fig. 1~~ combined the use of a self-organized knowledge map that clusters similar documents together [3] with simple "footprint" SNS [2]. In addition to that, an important feature of the Knowledge Sea system was the ability to annotate. The first version of Knowledge Sea provided a simple interface to annotate tutorial pages by adding written notes. To help student navigate back to pages with notes all cells and pages with notes were marked with a note icon (Fig. 1~~Fig. 1~~). Originally, all note were private: students were not able to see note marks or annotation made by others.

As a part of our evaluation of Knowledge Sea II we asked students several questions about annotation. We were interested whether students appreciated the annotation ability and whether they are interested to see annotations made by others and know which pages are annotated. The results were very encouraging (see Fig 6~~Fig 6~~). In addition, we have examined the notes that the students made for themselves and were pleased to discover that almost all notes could be categorized into three group: praise, problem, or general (34 general, 37 praise, 36 problem). This data motivated us to proceed with exploring the use of annotation as a source of a more reliable SNS that we called annotation-based SNS. The current version of annotation-based SNS was developed in two phases that were evaluated during Spring and Fall semesters of 2004. The remaining part of this section presents new features for annotation-based SNS introduced during these phases. The following section focuses on assessing the value of these features.

### 2.1 Phase 1: Public and Private Typed Notes

The evaluation result encouraged us to offer student an ability to make their annotations public and to choose one of three types of annotations (praise, problem, or general note). To make the presence of public annotation visible on the navigation level, we augmented the links inside the cell content window, and the links inside tutorial pages with a small sticky note icon inside a yellow square. The color of the background presents the density of public annotations and the color of the sticky note presents the density of the personal annotations. Therefore, students could make their navigation decisions based on annotation information in addition to traffic information provided in the previous phase.

We hypothesized that students would appreciate annotation ability more since they could see the more benefit of it. We expected to see effect of the presence of annotation on students' navigation behavior; i.e. students are more likely to visit pages with

annotation. We assumed that student would make use of specified annotation type to make their expression clearer. The main objective of this phase was assessing these hypotheses.

### 2.2 Phase 2: Stronger Navigation Support through Annotation

The main lesson we learned from previous phases were students need to be clearly motivated to write notes; i.e. the benefits of annotation should be clear to them. The annotation ability should be simple and does not make their learning process more difficult. To make the annotation ability simpler, we simplified the interface. We added the highlighting ability since we hypothesize that in e-learning environment highlighting can be easier to students than writing notes and in the evaluation of the second phase 70% of students expressed interest in highlighting ability.

To clarify the benefits of annotation to the students, in this phase we tried to offer stronger navigation support through annotation information provided by students; particularly we tried to offer stronger navigation support by using annotations' type information provided by students which was missing in the previous phase. Since in the previous phase, students would provide type for annotation but could note see that information while navigating through the space.

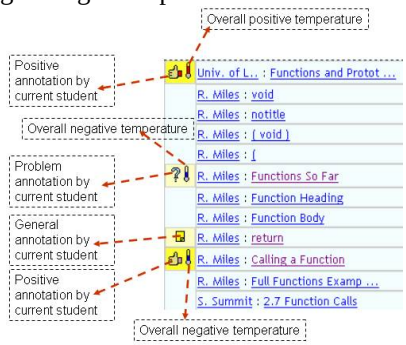


**Fig 2**-Cell content window with annotation based social navigation support

At the cell content window, the augmentation provides more information about the page associated with the link than just existence of the students' annotation. Here, the augmentation is in the form of an icon inside a small square. The background of the square gives information about the density of the annotations made by group of students while the icon gives the information about student's own annotation. The background gets darker as group of student make more annotations inside the page. In addition, unlike previous phase the link augmentation is not always a sticky note inside the yellow square. Here the icon is chosen based on the type of the personal annotation. The icons could be in different format: Thumbs up, question mark, and sticky note. Thumbs up icon represents that the current student has written a positive annotation (specified by thumb up type) or has highlighted part of the page. Likewise, question mark represents that the current student has written problem type annotation, and sticky note represent the

existence of general type note. A thermometer icon presents the temperature of group of students' annotations. The temperature will be warm when overall students have associated positive annotations with the page, and it gets cold when overall students have associated problem type annotations with the page. Fig 2~~Fig 2~~ presents part of the cell content window with annotation based social navigation support.

At the tutorial page level, same type of augmentation is provided for links inside the tutorial page. Therefore, the augmentation of the links helps students to navigate through resources inside Knowledge Sea by presenting the idea of other members of the community. Looking at the thermometer, students can decide to visit pages with positive annotations or they can ignore pages with negative annotations.

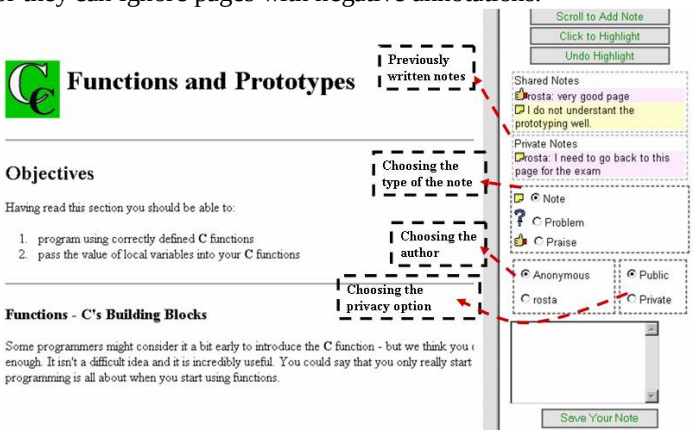


**Fig. 3**-Tutorial page with the annotation frame

Fig. 3~~Fig. 3~~ presents the annotation frame which is available at the right side of the tutorial pages. To highlight, a student can easily select part of the text inside the tutorial page and click on highlight button. Likewise, they can deselect the text. To write notes, students need to specify the followings: type of the note: praise, problem, and general; visibility of the note: public versus private note; authorship: we added the option to sign notes in this phase to motivate students to share their feedback with their classmates. Inside the annotation frame, students can view previously written notes by themselves and public notes written by others.

In this phase we hypothesize that students will express more interest toward annotation ability since the benefit is clearer to them. We hypothesize that the usage of annotation ability will be increased because of clearer benefits of the annotations and highlighting ability as well. We expect to see stronger correlation between annotated pages and students' navigation behavior and higher usage of the system since it is easier for students to find relevant information. We suppose that usage of specifying types for notes will be higher since the benefit of it is clearer. Also, we hypothesized that students will be more likely to specify their name while writing public notes than staying anonymous because of the implicit credit given to providing information for others.

# 3 Evaluation

We assessed the effectiveness of the system and evaluated our hypotheses through a 3 semester user study. The study was done in an introductory C programming course in school of information science in university of Pittsburgh. During the study students' interaction with the system has been tracked. The evaluation is done through analyzing students' logs in addition to running an optional questionnaire at the end of the semester. Looking at students' logs, we evaluated the effect of annotation on students' navigation, and overall usage of the system. We looked at students' opinion about annotation ability in the system, interest in visiting pages annotated by others, and sharing annotation with others. The rest of this section describes the evaluation of the system in details.

## 3.1 Effect of Annotation on Usage of the System

Fig. 4~~Fig. 4~~ presents the usage of three versions of the system over three semesters. The three versions differ only in the annotation ability described in section 2. Fig. 4~~Fig. 4~~ shows that the median visits and clicks have been increased over the semesters. Looking at the number of annotation over these two semesters, we can see that students has made more annotation over the first semester; however, closer analysis of the annotations shows that 97% of these annotation are made by just two students. Therefore, we can assume that generally more student have been interested in using the annotation ability in spring semester. This semester, we focused more on enriching the annotation ability of the system and using annotation information to provide navigation support to students. Fig. 4~~Fig. 4~~ shows that new modification of the system has been very successful in encouraging students to use the system both in terms of visiting and annotating.

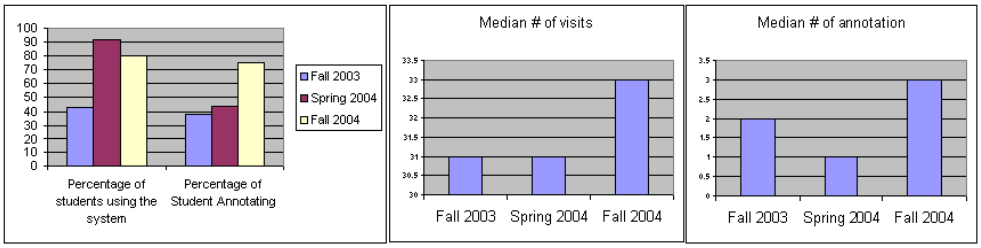


**Fig. 4**-Overall usage of KS system over the first 3 months of the 3 semesters of users study

## 3.2 Effect of Annotations on Students' Navigation Behavior

To analyze the effectiveness of annotation based navigation support, we compared navigation behavior of students with regards to presence of annotation. We looked at documents with public annotations over this semester and last semester and analyzed the

percentage of activity on each document before and after presence of the public annotation. We also looked at documents with public and private annotation to understand the effect of annotation on revisiting of the document by the author of the annotation.

**Effect of annotation on group navigation behavior:** To evaluate the effect of public annotation on navigation behavior of students we computed the normalized percentage of activity before and after presence of public annotation. To normalize we divided the number of activities over the number of possible days to perform the activity. Activity before annotation is divided by the number of days from the first day of using the system till the date of first public annotation and activity after annotation is divided by the number of days after the first public annotation till the last day of using the system. As shown in the left hand side of the **Fig. 5**~~**Fig. 5**~~ in most cases more than 50% of the activity is done after the presence of the public annotation and the difference is statistically significant (p-value=0). The same result is observed over fall 2004 as shown in the right part of **Fig. 5**~~**Fig. 5**~~and again the difference is statistically significant (p-value=0).

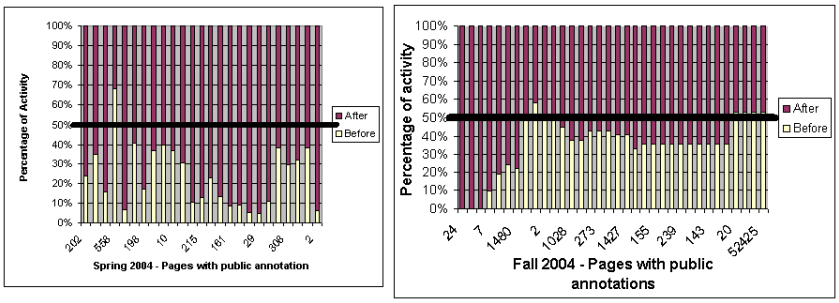


**Fig. 5**-Effect of public annotation in studets' activity

**Effect of personal annotation on personal navigation behavior:** In analysis of effectiveness of annotation we looked at the effect of annotation on revisiting a page by the author of the annotation. Over the spring 2004 semester, overall 12 students had been annotating. The data shows these students are more likely to revisit a page that they have annotated than a page that doesn't have their own annotation. Overall 41% of pages with self-annotation were self-revisited while just 17% of not self-annotated pages were self-revisited. Similarly, we can observe an effect on personal annotation on revisit in this semester. Over the first 3 months of this semester, 5 students have been annotating. The data shows that 84% of the personal annotated pages have been revisited by the author of the annotation while these students have been revisiting 23% of the pages without their personal annotation.

**Effect of thermometer on group navigation behavior:** As mentioned before, pages with typed (praise or problem) annotation were augmented with a thermometer icon presenting the overall temperature of the annotation. We looked at the effect of presence of positive temperature in navigation behavior of students. We observed that the

navigation behavior on pages with positive temperature is not very different from pages with neutral or even negative temperature. After more careful analysis of students' annotation we figured out that specifying type of annotation is not very clear to the student. First, many obviously positive annotation were typed by students as general. Table 1~~Table 1~~ shows that more than 50% of general annotation are praise. We hypothesis that the interface could have an effect on this since the type option was located quite far from the note box. We have changed the interface for our new study and we are testing our hypothesis. Second, problem type annotation was being used more as reporting some problem with the page to the teacher that can be due to our wrong wordings. Therefore, the temperature was not showing the right information since many pages could have more positive temperature and pages with negative temperature were not in fact negative pages.

Table 1 - Usage of type of annotations

| | **Total Number of Annotations** | **Praise** | **General** | **General but Praise** |
|---|---|---|---|---|
| **Spring 2004** | **41** | **16** | **25** | **17** |
| **Fall 2004** | **51** | **24** | **21** | **11** |

**Correlation of interest and annotation:** In addition to effect of annotation in navigation behavior, we looked at the correlation on interest and presence of annotation. Checking data of two semesters we discovered that students visit annotated pages more often than non-annotated pages. The average visit (the number of visits divided by the possible number of documents to be visited) on annotated pages is significantly different from average visit on not annotation pages over both semesters (p-value=0).

### 3.3 Evaluation through Questionnaire

As mentioned before, we ran an optional questionnaire at the end of each semester to collect more explicit feedback from students regarding different aspects of the system. Related to the discussion of this paper, we asked students' opinion about annotation ability, their interest level in sharing annotation with others, and their interest level in visiting annotated pages with others.

As it can be seen in **Fig 6**~~**Fig 6**~~ overall about 60% of students appreciated the ability to annotate and very few have found the annotation ability negative. Moreover, the graph shows that modification of the second phase has increased the appreciate level of students. As it can be seen in the graph large percentage of students are interested to access pages with annotation of others, and the interest is much higher among students of spring semester that were able to see this information. We asked student of spring semester who were able to use annotation based navigation support about how they found this feature. About 70% of students found annotation based navigation support positive.

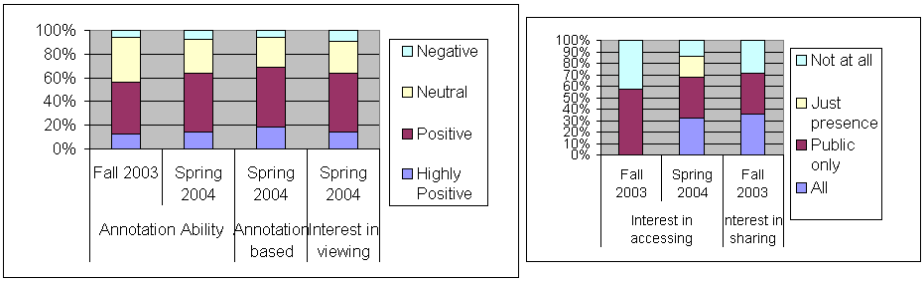


**Fig 6** - Students' opinion about annotation feature of the system

## 4 Previous Work

Several e-learning systems have been developed using the idea of social navigation. Most relevant to our project are CoFIND [6] and Educo [7]. CoFIND is a self-organized learning environment that organizes the online resources through the process of voting done by learners. Learners can associate different types of qualities (such as “simple”, “good for beginners”) with each resource to help with the organization of the resources. Although CoFIND has been pretty successful among its users, it relies heavily on explicit feedback. Providing explicit feedback can interfere with the students’ learning process and can increase students’ extraneous cognitive load. Educo is a collaborative learning environment that supports social navigation in direct and indirect way. The direct social navigation is supported through real-time discussion via chat rooms. The indirect social navigation is supported through annotating the resources based on number of visits. Although direct social navigation is interesting, what is more interesting and important to us is indirect social navigation. Indirect social navigation is well suited for online settings that people access the resource on individual bases on distinct times and locations. Direct social navigation can offer very little help to those who are not able to participate in the real time discussion. It is hard to restore the discussion and more difficult is associating the discussion with the content of the resource. The discussion could be totally irrelevant to the associated resource. In terms of indirect support of social navigation, Educo relies on simple implicit feedback from students: the number of visits. Although Educo enables learners to annotate document, this information is not used for navigation support.

## 5 Conclusion

The problem of information overload is very serious problem in online leaning and day by day it becomes more challenging to provide the right information to the right user. Social navigation and group modeling seems a promising idea in providing navigation support

inside community of online learners. However, the challenges of collecting feedback from learners make the social navigation support very difficult. Our result shows that annotation-based social navigation support has attractions for the learners. Yet, the learners have to be motivated to annotate the tutorial pages. As the future direction of this work, we are planning to provide bridges from students' annotation to course material by letting student bookmark pages as related to lectures or assignments. We believe this will give more motivation and clearer navigation support to students through annotation.

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