Techniques for user adaptive display of information in the Knowledge Sea system

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1. The Knowledge Sea System

1.1 About the Knowledge Sea System

The Knowledge Sea system (Brusilovsky, Rizzo 2002) is a map-based navigation support tool for horizontal navigation in educational courseware, specifically C tutorials that are available on the Internet.

The Knowledge Sea system uses 'Self Organizing Maps' (SOM), a neural network technique, to organize the individual pages in the tutorials into clusters. Documents in a cluster are similar to each other based on the keywords used in those documents, and hence generally address similar concepts.

The SOM that is generated after learning the network is displayed as a two-dimensional Map with no. of cells equal to the no. of nodes in the middle layer of the SOM. Cells that are closer to each other on the map are more similar to each other than those that are farther apart.

The SOM assigns a document to a particular cell whose mean vector is most similar to the document's vector. Hence there is a list of documents associated with each cell.
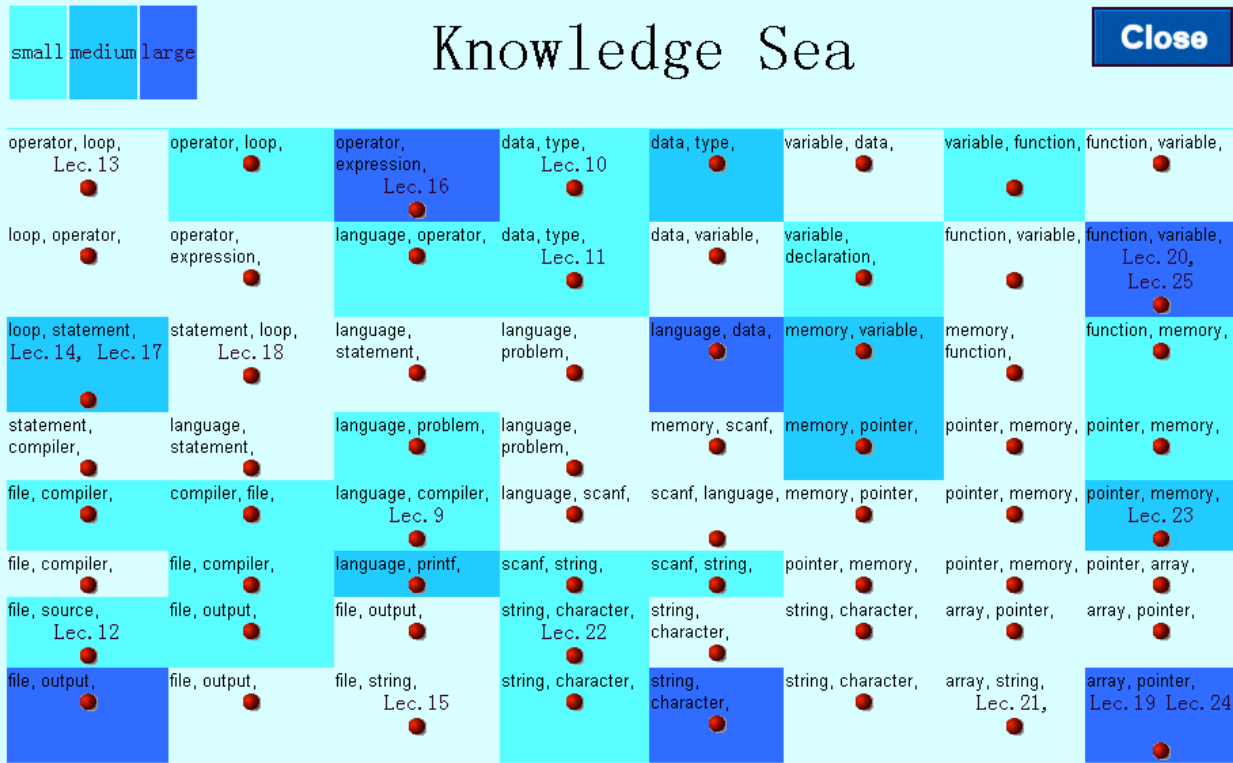
1.2 The Knowledge Sea Interface

The Knowledge Sea interface has 2 distinct parts :
1. Map Interface
2. Cell Contents Interface

The map interface displays the SOM map, whereas the Cell contents interface displays the list of documents assigned to a particular cell.

1.2.1 Map Interface

The map implicitly conveys to the viewer the concept addressed by a cell and the relative no. of documents in each cell. It also shows landmarks on the map, that serve as starting points for the navigation. A landmark is generally a set of lecture slides for the C Programming course, which students use as a reference point on the map. Each landmark is assigned to a cell that most closely matches the topic addressed in the slides.

small medium large **Knowledge Sea** **Close**

operator, loop, Lec. 13	operator, loop,	operator, expression, Lec. 16	data, type, Lec. 10	data, type,	variable, data,	variable, function,	function, variable,
loop, operator,	operator, expression,	language, operator,	data, type, Lec. 11	data, variable,	variable, declaration,	function, variable,	function, variable, Lec. 20, Lec. 25
loop, statement, Lec. 14, Lec. 17	statement, loop, Lec. 18	language, statement,	language, problem,	language, data,	memory, variable,	memory, function,	function, memory,
statement, compiler,	language, statement,	language, problem,	language, problem,	memory, scanf,	memory, pointer,	pointer, memory,	pointer, memory,
file, compiler,	compiler, file,	language, compiler, Lec. 9	language, scanf,	scanf, language,	memory, pointer,	pointer, memory,	pointer, memory, Lec. 23
file, compiler,	file, compiler,	language, printf,	scanf, string,	scanf, string,	pointer, memory,	pointer, memory,	pointer, array,
file, source, Lec. 12	file, output,	file, output,	string, character, Lec. 22	string, character,	string, character,	array, pointer,	array, pointer,
file, output,	file, output,	file, string, Lec. 15	string, character,	string, character,	string, character,	array, string, Lec. 21,	array, pointer, Lec. 19 Lec. 24

Each cell has a list of the keywords that are most representative of the cluster to which the cell belongs. Hence some cells have the same keywords displayed as they belong to the same cluster. These keywords give an idea of the concepts addressed by documents in that cell. The no. of keywords displayed is limited to 2 to avoid excessive cluttering of the map.

Landmarks are displayed as separate links below the keywords with labels indicating the lecture no. e.g. "Lec.10"

The color of the cell indicates the no. of documents in each cell. The darker the color, the more no. of documents are present in that cell.

Red dot images in the cells serve as links to open the Cell contents interface.

1.2.2 Cell Contents Interface

The Cell Contents interface is used to display the list of documents assigned to the particular cell. It is displayed when the user clicks on the red dot in the cell.

The cell contents window displays an extended list of keywords than those displayed in the cell on the map interface, to give a better idea of the concepts addressed by the documents.
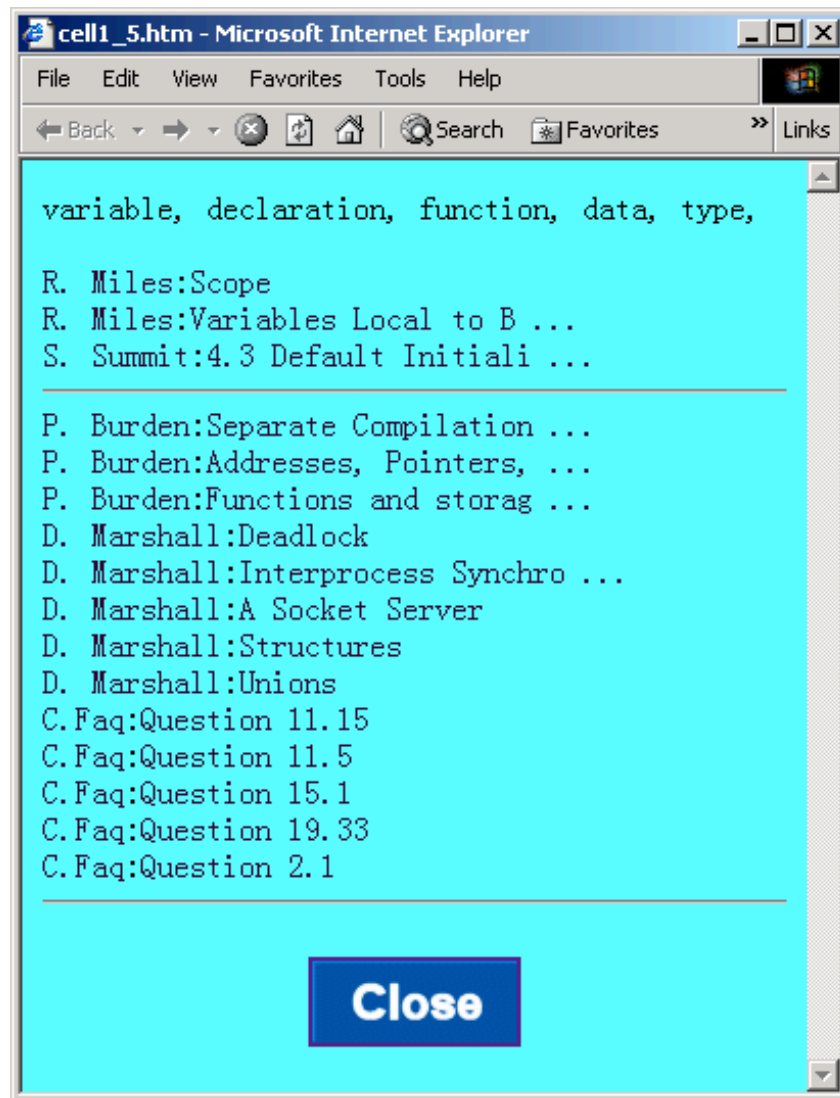
It displays the list of documents assigned to that cell in the following format

source name : page title

Where,

Source name is the name of the tutorial, used to identify which tutorial the page belongs to.

page title is the title of the document. It serves to further clarify the topic addressed by the document.

```
cell1_5.htm - Microsoft Internet Explorer          _ □ X

File    Edit    View    Favorites    Tools    Help

← Back  ▼  →  ▼  ⊗  ⬚  ⌂   🔍Search  📑Favorites  »  Links

variable, declaration, function, data, type,

R.  Miles:Scope
R.  Miles:Variables Local to B ...
S.  Summit:4.3 Default Initiali ...

P.  Burden:Separate Compilation ...
P.  Burden:Addresses, Pointers, ...
P.  Burden:Functions and storag ...
D.  Marshall:Deadlock
D.  Marshall:Interprocess Synchro ...
D.  Marshall:A Socket Server
D.  Marshall:Structures
D.  Marshall:Unions
C.Faq:Question 11.15
C.Faq:Question 11.5
C.Faq:Question 15.1
C.Faq:Question 19.33
C.Faq:Question 2.1

                  Close
```

Clicking on the source name opens the main / root page of the tutorial hierarchy for that particular tutorial source.

Clicking on the document title opens a new window that loads the document.

1.3 Tracking User Activity

User activity was tracked so as to gain more insight into how the users navigate the map. The type of user activity tracked is :

1. The action of clicking on a cell.
2. The action of visiting a particular document.

1.4 Identified problems

1.4.1 Inflexible implementation

The implementation was essentially a set of html pages for each cell content window and the main map. All the data about the document titles, their links, etc. was hard coded into the html pages.
This caused problems with fixing dead links when entire tutorials were shifted to a new location on the Internet. Fixing the dead links essentially involved going to each individual page and changing the links of all the documents belonging to the source in question to point to the new location.
Changing certain display properties of the map like no. of keywords displayed, or map colors etc. was simply not an option due to the extensive work involved of making the changes to each individual page.

1.4.2 Distracting color usage

The usage of different colors to indicate the no. of documents assigned to that cell was found to be distracting to the users. This is possibly due to the apparent random arrangement of differently colored cells on the map.

1.4.3 Unreliable tracking of user activity

The user activity was logged to a buffer whenever the user performed an action that was being tracked. The buffer was stored to the logs only when the user clicked on the CLOSE button displayed on the top right of the map interface or the cell contents interface.
The problem with this approach is that users didn't necessarily click on the CLOSE button to close the window. They sometimes used alternative techniques like ALT+F4 key combination or using the standard windows close button. When this happened, all the buffered user activity was lost as it wasn't written to the logs. This resulted in unreliable user activity tracking.

2. Knowledge Sea v2.0

The new system uses a database to store all the information about the pages in the map, in addition to storing the user lists, their visit counts, and annotations. The map is dynamically generated using the database. This made the implementation very flexible and easy to modify.

Several new interface additions were made to support annotations and user and group traffic indications.

2.1 The updated Knowledge Sea Interface

The 2 distinct parts of the interface are explained below :

2.1.1 Map Interface

operator, loop, expression L11	operator, loop, expression	operator, expression, value L14	data, type, variable L8	data, type, variable	variable, data, type	variable, function, declaration	function, variable, declaration
loop, operator, statement	operator, expression, loop	language, operator, type	data, type, variable L9	data, variable, type	variable, declaration, function	function, variable, declaration	function, variable, declaration L18 L23
loop, statement, operator L12 L15	statement, loop, operator L16	language, statement, problem	language, problem, work	language, data, problem	memory, variable, structure	memory, function, pointer	function, memory, pointer
statement, compiler, loop	language, statement, compiler	language, problem, run	language, problem, scanf	memory, scanf, language	memory, pointer, structure	pointer, memory, function	pointer, memory, function
file, compiler, include	compiler, file, language	language, compiler, run L7	language, scanf, problem	scanf, language, memory	memory, pointer, scanf	pointer, memory, array	pointer, memory, array L21
file, compiler, include	file, compiler, run	language, printf, scanf	scanf, string, printf	scanf, string, character	pointer, memory, string	pointer, memory, array	pointer, array, memory
file, source, include L10	file, output, function	file, output, printf	string, character, printf L20	string, character, scanf	string, character, scanf	array, pointer, string	array, pointer, memory
file, output, source	file, output, input	file, string, output L13	string, character, printf	string, character, print	string, character, array	array, string, pointer	array, pointer, string

The text size was reduced so as to accommodate more keywords on the map and make more space for the icons.

The main map indicates the following measures :
1. User Traffic : It is the no. of visits made by the user to a particular cell. It is indicated using the icon. There are 5 different levels of user traffic, which are displayed using the same icon filled with different darkness levels of blue as shown below :

More   Less

2. Group Traffic : It is the no. of visits made by the user's group members to the particular cell. It is indicated by the darkness level of the cell background color. There are 43 different darkness levels used to indicate group traffic.
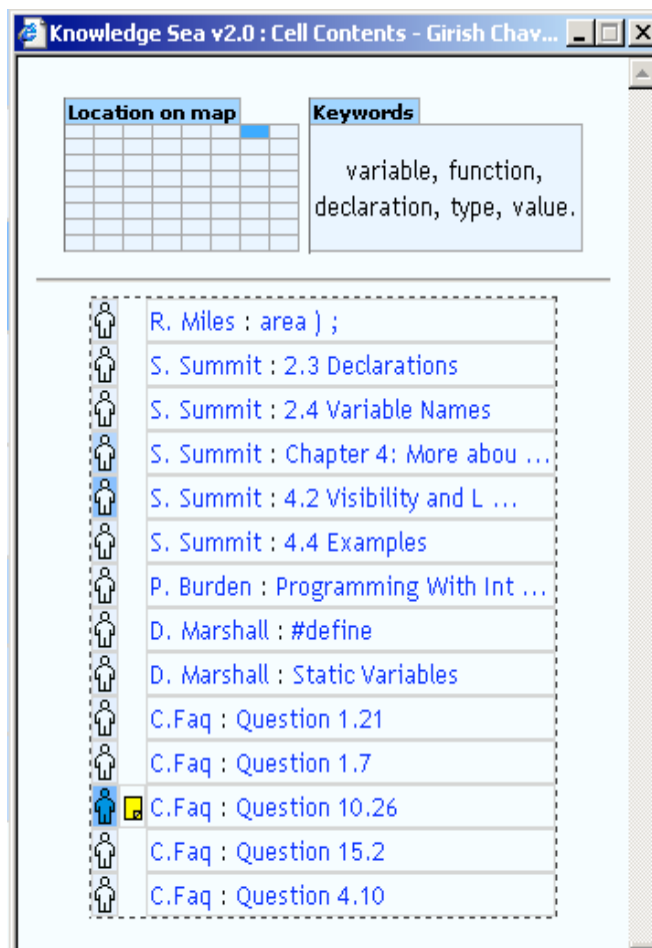
3. No. of documents in the cell : It is indicated using 3 different levels of the 'stack of pages' image.

More   Less

4. Annotations : If the user had annotated any pages within the cell then the stack of pages image was slightly changed to indicate presence of annotations

More   Less

2.1.2 Cell Contents Interface

The Cell Contents interface was broken up into 3 different sections

1. Location on map : It displays a small replica of the main map and colors the corresponding cell on the map whose contents are displayed in the window.
2. Keywords : More keywords are displayed here to give the user a better idea of the type of documents in this cell.

3. The pages table : The pages table displays the user and group traffic for each of the pages, using a similar interface metaphor to that used in the main map. It also indicates which pages are annotated by displaying a small ▣ icon beside the link to that page.

2.2 Updated user tracking

In addition to tracking the same activities that were tracked by the original Knowledge Sea system described in section 1.3, the user tracking module also tracked the action of the user annotating a page.

Level 1 : The database maintains a count of the no. of visits made by the user to a particular page. This value is used to calculate no. of visits made by the group to the page, no. of visits made by the user to the cell and no. of visits made by the group to the cell.

Level 2 : Every time the user clicks on a cell, to open it, a log entry is made for that action in the User Modeling engine. This enables us to know if the user actually visits a page within the cell after opening the cell contents window for it.

2.3 Details of traffic level calculation and presentation

Darkness level of color is used to indicate the level of user/group traffic. While the background color is used to indicate the group traffic, the color the 🧍 icon is used to indicate the user traffic. For working with the lightness component of colors easily, the colors are first converted to their HLS (Hue, Lightness, Saturation)model representations.

2.3.1 Traffic Level computation

4 different traffic types are used :
1. User traffic to page.
2. User traffic to cell.
3. Group traffic to page.
4. Group traffic to cell.

The formulae for calculating the color level based on the traffic remain the same for all the 4 types. The user traffic to a page was logged in the database every time the user visited a page. All the other traffic types are derived from this value as follows :

Let the visits made by ith user to P_kth page be denoted by v_{iP_k}

Let the visits made by ith user to C_jth cell be denoted by v_{iC_j}

Let the current group of the user be G.

Then the visits made by the Gth group to P_kth page be denoted by vg_{P_k}

and the visits made by the Gth group to C_jth cell be denoted by vg_{C_j}

We define

$$vg_{P_k} = \sum_i \{v_{iP_k} \mid i \subset G\}$$

$$v_{iC_j} = \sum_k \{v_{iP_k} \mid P_k \subset C_j\}$$

$$vg_{C_j} = \sum_i \{v_{iC_j} \mid i \subset G\}$$

We also need the maximum values for these traffic levels for further calculations.

We have

❑ $\max(v_{iP_k}) \forall k$ = Estimated maximum total no. of visits to any single page by any user. This has been fixed at 10

❑ $\max(vg_{P_k}) = |G| * \max(v_{iP_k})$
    where,
        $\max(vg_{P_k})$: Maximum no. of visits possible for the current page. (Maximum group traffic to a page)
        $|G|$: No. of users in the group G

❑ $\max(v_{iC_j}) = |C_j| * \max(v_{iP_k})$
    where,
        $\max(v_{iC_j})$: Maximum no. of visits to a cell by any user. (Maximum group traffic to a cell)
        $|C_j|$: No. of documents assigned to cell C_j

❑ $\max(vg_{C_j}) = |C_j| * |G| * \max(v_{iP_k})$
    where,
        $\max(vg_{C_j})$: Maximum no. of visits possible for the current cell. (Maximum group traffic to a cell)
        $|C_j|$: No. of documents assigned to cell C_j

2.3.2 Darkness level of color computation

The darkness level of the color depends upon the traffic level computed in section 2.3.1. As the darkness level calculations remain the same irrespective of the type of traffic,

Let

t : Traffic level
max(t) : maximum value of t.

A lightest and darkest color for the map was selected. All colors on the map would be lightness gradations between these two colors. We chose 43 different lightness levels of color between the lightest and the darkest color. This was done so that adjacent gradations are still visually distinct from each other.

We have
0 < t < max(t) $\forall$ *t*

To calculate the color level we map all the datapoints within the above interval to

0 < cl < max(cl)

Where,

cl : Color level for current cell.
max(cl) : Maximum number of distinct levels of color. Fixed at 43.

We believe that it is more beneficial for the user to know the difference between the visits to two cells on the map, if say, one has been visited 2 times and the other has been visited 15 times. On the other hand, it is not very beneficial for the user to know the difference between the cells, if one has been visited 1000 times and the other 1020 times. Hence we want to make the color changes so that, when the traffic levels are relatively low, small changes to the traffic, should be immediately reflected with the change in color, and after the no. of visits across cells become very high, then a larger difference between the visits of two cells would be required for their color to be different. We solve this problem by using a logarithmic transformation to do the mapping.

We define a mapping function N() to do this as follows :

$$N(x) = \begin{cases} \ln(x) & x > 1 \\ 0.2 & x = 1 \\ 0 & otherwise \end{cases}$$

N(x) = 0.2 for *x=1* because *0.2 < ln(2),* which is the next possible traffic level after 1.

Finally the normalization step is performed as follows to get the color level (cl):

$$cl = \left(\frac{N(t)}{N(\max(t))} \right) * \max(cl)$$

Hence colorlevel (cl) gives us the color to be used to represent that traffic level.

Once the color has been calculated in the HLS model, it is converted to RGB model so that it can be displayed by the browser.

2.4 Database Schema

Map Layout [Table name : MAPDATA] *

Attribute name	Data type	Size	Required?	Reference	Description
cellid	tinyint	default	Yes	None	
rowno	tinyint	default	Yes	None	
colno	tinyint	default	Yes	None	

* This table relates the cellid, to the row and column nos. Cellid is used in the database to refer to any cell on the map.

Keyword Information [Table name : KEYDATA]

Attribute name	Data type	Size	Required?	Reference	Description
keyid	smallint	5	Yes	None	
keyword	char	25	Yes	None	

Map Keywords Relation [Table name : MAPKEY]

Attribute name	Data type	Size	Required?	Reference	Description
cellid	tinyint	3	Yes	MAPDATA.cellid	Reference to map layout table
keyid	smallint	5	Yes	KEYDATA.cellid	Reference to Keyword Information table
position	tinyint	3	No	None	Used to order keywords in the cell

Tutorial Source Info. [Table name : SOURCEDATA]

Attribute name	Data type	Size	Required?	Reference	Description
sourceid	tinyint	3	Yes	None	
sourcetitle	varchar	100	No	None	Title of the page
baseurl	varchar	50	Yes	None	Absolute url of the tutorial
maindocid	mediumint	8	Yes	DOCDATA.docid	docid of the main page of the tutorial

Page Information [Table name : DOCDATA]

Attribute name	Data type	Size	Required?	Reference	Description
docid	mediumint	8	Yes	None	
doctitle	varchar	100	No	None	Title of the page
doclink	varchar	50	Yes	None	Local url of the page (appended to base url)
sourceid	tinyint	3	Yes	SOURCEDATA.sourceid	Reference to Source Information table

Map Page Relation [Table name : MAPDOC]

Attribute name	Data type	Size	Required?	Reference	Description
cellid	tinyint	3	Yes	MAPDATA.cellid	Reference to map layout table
docid	mediumint	8	Yes	None	Reference to the Page Information table

Landmarks Information [Table name : LANDMARKS]

Attribute name	Data type	Size	Required?	Reference	Description
cellid	tinyint	3	Yes	MAPDATA.cellid	Reference to map layout table
docid	mediumint	8	Yes	DOCDATA.docid	Reference to the Page Information table
abbrname	varchar	10	No	None	Name displayed on the map

User Visits Counts [Table name : COUNTS]

Attribute name	Data type	Size	Required?	Reference	Description
userid	varchar	10	Yes	None	
groupid	int	10	Yes	None	

docid	mediumint	8	Yes	None	Reference to the Page Information table
visitedcount	mediumint	8	No	None	No. of visits by user [userid] to page [docid]
annotatcount	smallint	5	No	None	No. of annotations by user on the page

User Annotations [Table name : ANNOTATIONS]

Attribute name	Data type	Size	Required?	Reference	Description
userid	varchar	10	Yes	None	
groupid	int	10	Yes	None	
docid	mediumint	8	Yes	None	
annotation	blob		No	None	The annotation made by user on the page

3. User Survey Results & Analysis

The user survey was conducted using a questionnaire containing 22 multiple choice questions, 1 multiple answer question and 1 open ended question. The goal of the questionnaire was to judge the effectiveness of the system in organizing the tutorial information on the whole, and to judge the effectiveness of the interface design features implemented. The questionnaire was largely based on the questionnaire used to evaluate the original Knowledge Sea system. New questions were added to evaluate the new interface features implemented like user visits traffic and annotation support.

The system was evaluated by the students of the C Programming class offered at the School of Information Sciences at University of Pittsburgh.
Out of the 30 students that took the class, 24 used the KnowledgeSea system, and 14 of those students responded to the survey. Only survey results of students who actually used the system were considered when evaluating the statistics.

3.1 Detailed Survey Results

Shown below are the detailed results of the survey.

Question 1: Multiple Choice The goal of the KnowledgeSea map is to help the student to access free online tutorials on C language. To what extent the system achieves this goal	% Responses
completely	14%
quite well	64%
not quite well, but it can sometimes be of help	21%
it does not help at all	0%
Question 2: Multiple Choice Was the overall idea and purpose of the map (spreading the universe of C knowledge over the 8X8 map, attaching resources to cells, showing where the lectures belong to and indicating user and group traffic) easy to grasp?	% Responses
Yes, very easy	36%
Quite easy, though a few points were unclear	43%
Not very straightforward, but I think, I have finally got it	21%
Hard. I still do not understand why do we need KnowledgeSea and how it can help	0%
Question 3: Multiple Choice The overall interface for the KnowledgeSea map (the way you can view the map, the way you can find and read tutorial pages) was:	% Responses
Very good	36%
Good	43%
Far from perfect: has some problems or lacks some features	21%
Poor: has some major problems	0%

Question 4: Multiple Choice The tutorial pages connected to the same cell of the map were	% Responses
strongly related to each other by content	21%
reasonably related to each other by content	71%
poorly related to each other by content	0%
not related to each other by content	0%
I can't judge	7%
Question 5: Multiple Choice For a pair of neighboring cells, the overall topics and the connected tutorial pages were	% Responses
strongly related to each other by content	0%
reasonably related to each other by content	93%
poorly related to each other by content	7%
not related to each other by content	0%
I can't judge	0%
Question 6: Multiple Choice The tutorial pages that you have found in the cell with a lecture name and around this cell were	% Responses
almost always relevant to the lecture content	36%
often relevant to the lecture content	57%
sometimes relevant to the lecture content	7%
never relevant to the lecture content	0%
Question 7: Multiple Choice The content of the C tutorial pages you have found with the help of KnowledgeSea system was	% Responses
Almost always good and helpful for understanding	14%
Often good and helpful	43%
Sometimes good and helpful, but could be much better	43%
Poor and not helpful at all	0%
Question 8: Multiple Choice Knowledge Sea uses a "Stack of pages" (icon) icon to indicate the no. of tutorial pages within a particular cell. One-page-stack indicated cells with few pages, two-page-stack indicated reasonable number of pages, and three-page-stack indicated cells with many pages. What do you think about this feature?	% Responses
It is a clever interface element and extremely helpful	43%
It is a good idea. But it would be more helpful to show more than 3 levels of the stack of documents would be used.	14%
The different levels of stack of documents look very similar and hence not very helpful	14%
I didn't use it much, it doesn't matter to me how many pages are there within a particular cell.	29%

Question 9: Multiple Choice The KnowledgeSea system attempt to show you how often you and your group have visited each document and each cell. On the main map the no. of visits made to a cell by members of your group is indicated by the darkness of the blue color of the cell background. The no. of visits to the cell by yourself is indicated by the darkness of blue color of the 'human figure'( ) icon in displayed in the cell. The more the no. of visits, the darker the color was in both cases. Do you think that the very idea to show the no. of visits made to the cells right on the main map in this way was helpful?	% Responses
The indication of my own traffic and that of my group's traffic are both useful.	50%
The indication of my own traffic is useful, but indication of my group's traffic isn't very useful	7%
The indication of my group's traffic is useful but indication of my own traffic isn't very useful	36%
The indication of any traffic isn't useful and only adds to the confusion.	7%
Question 10: Multiple Choice The current version of the Knowledge Sea system used different darkness levels of blue for the cell background on the main map to indicate the no. of visits made by members of your group to the cell. This way to show the number of visits made by the group was	% Responses
Very clever and helpful interface feature	50%
A reasonably useful way	29%
A somewhat reasonable way, but with many problems	21%
Completely wrong idea	0%
Question 11: Multiple Choice Knowledge Sea used different darkness levels of blue for the "human figure" icon in the cell on the main map to indicate the number of your visits to the cell. How would you rate this approach to show your personal traffic?	% Responses
Very clever and helpful interface feature	43%
A reasonably useful way	43%
A somewhat reasonable way, but with many problems	14%
Completely wrong idea	0%
Question 12: Multiple Choice In each "cell contents" window, the number of visits made to a particular page by members of your group is indicated by the darkness of the blue color of the small rectangular box at the left of the link to the page. The number of visits you made to the cell is indicated by the darkness of blue color of the "human figure" ( ) icon displayed in that box. The more visits, the darker the color was in both cases. Some of you may notice that the same approach was used to annotate links between pages inside each tutorial Do you think that showing visually the number of group/personal visits to a page near the link to this page in the "cell contents" window and on tutorial pages is helpful?	% Responses
The indication of my own traffic and that of my group's traffic are both useful.	43%
The indication of my own traffic is useful, but indication of my group's traffic isn't very useful	14%
The indication of my group's traffic is useful but indication of my own traffic isn't very useful	36%
The indication of any traffic isn't useful and only adds to the confusion	7%
Question 13: Multiple Choice Using different darkness levels of blue for the "human figure" icon (in the cell contents window and inside tutorial pages) to indicate your no. your personal visits to a particular page was	% Responses
Very clever and helpful interface feature	43%
A reasonably useful way	43%

A somewhat reasonable way, but with many problems	14%
Completely wrong idea	0%
Question 14: Multiple Choice Using different darkness levels of blue of the small rectangular box to the right of a link to each tutorial page (in the cell contents window and inside tutorial pages) to indicate the no. of visits made to a page by members of your group was	% Responses
Very clever and helpful interface feature	43%
A reasonably useful way	36%
A somewhat reasonable way, but with many problems	21%
Completely wrong idea	0%
Question 15: Multiple Choice The display of a small map in the cell contents window to indicate which cell the current window's contents belong to is	% Responses
1. Extremely useful and helps me not to get lost on the map.	14%
2. Very useful, but it would be great to be able to navigate from this small map too.	50%
3. Somewhat useful, but I still get confused as to the location of the cell on the actual map.	14%
Not useful at all, it is a waste of space on the cell contents window.	21%
Question 16: Multiple Choice The ability to annotate tutorial pages and to come back to read these annotations was	% Responses
One of the most important features of the system	14%
Quite useful	50%
Sometimes helpful, but most often useless	29%
Completely useless	7%
Question 17: Multiple Choice The use of a small yellow sticker on the "stack of pages" icon ( ) in the cell on the main map, and beside the page title in the "cell contents" windows to indicate the presence of your annotations was	% Responses
Very clever and helpful interface feature, it is very intuitive	50%
A reasonably useful way.	36%
A somewhat reasonable way, but it is confusing at times.	7%
Completely wrong idea	7%
Question 18: Multiple Choice Currently you can view only those annotations that you have made. Others members of your group cannot view your annotations and you cannot view theirs. Moreover, none of you is even aware which pages were annotated by others. You only can see where your own annotations are located. However, there are several other ways to share the annotations. In the sense of allowing other people to access your annotation, what you would consider as the best option:	% Responses
I wouldn't mind if other students can view all my annotations	36%
I am ready to allow my classmates to view my annotations as long as I can specify some of my annotations as private, so that they cannot be viewed by others.	29%
I would not mind people to know that I have annotated a page (i.e., to see a "yellow sticker" icon on the pages I have annotated), but I do not want them to read any of my annotations.	7%
I am not comfortable with other people reading my annotations or even knowing that I have annotated a page	29%

Question 19: Multiple Choice To what extend you would be interested to access annotations made by other students in your group?	% Responses
I would like to view other people's annotations, it is helpful to know what other people think about the page	14%
I would like to view other people's annotations as long as they explicitly made them available to everyone. I do not want to read "private" annotations	57%
I would like to know which pages have been annotated by other students of my group - just to make sure that I have not missed some important pages. However, I am not interested to read their annotations	0%
I am not interested even to see which pages have been annotated by other members of my group. I want to keep the annotation feature completely for the private use	29%
Question 20: Multiple Choice Imagine that the KnowledgeSea system can adapt to you knowledge and can suggest (for example, highlight) the map cells and links to tutorial pages that present content you likely need to read to get a better understanding of the material. This feature will be	% Responses
Totally great because it will help me to get straight to the most important pages	57%
Useful, but not very much - just give me a list of pages, and I figure out which is best for me	29%
Not very useful because it only judges the content of the pages, not the style of presentation. For me the style of presentation is most important	14%
Useless because I am not going to use KnowledgeSea for different reasons	0%
Question 21: Multiple Choice I think that in the context of a C programming course a KnowledgeSea system	% Responses
should become one of the key course tools	7%
can be very helpful	79%
could be useful for some students	14%
hardly worth time spent for its development	0%
Question 22: Multiple Answer Imagine that you have a personal handheld computer (like Jornada or Palm) that can connect to internet from anywhere and provides an access to the KnowledgeSea tool. Where you would consider to use it	% Responses
right in the classroom during the lecture	43%
at home or in the library when doing reading part of the assignment	93%
at home or in the lab when working on quizzes or programming assignments	79%
from anywhere (bus, park, etc) to examine the material when I have some spare time	50%

3.2 Results Analysis

All the respondents felt that the Knowledge Sea system was helpful to some extent and achieved its goal of helping students access free online tutorials on C language. The general interface of the map was found to be good by 79% of the respondents, the rest felt that it could be improved further.

3.2.1 System effectiveness with respect to organizing information

None of the respondents thought that the pages within a cell were not related at all. With regards to relation of pages in neighboring cells, 93% thought that they were reasonably related.

Landmarks were found to be effective too; all respondents felt that the pages within the cell with a landmark were relevant to some extent with the landmark content.

3.2.2 System effectiveness with respect to interface design for indicating traffic

Roughly half the respondents felt that the indication of their own traffic and their group's traffic was useful. In general, respondents found the indication of group traffic more useful than the indication of their own traffic. Very few(7%), found the indication of any kind of traffic useless.

All the respondents agreed that using different levels of darkness of color to indicate level of traffic was the right idea. However, roughly 18% of the respondents felt that there was scope for improvement in this area.

3.2.3 System effectiveness with respect to annotations feature

In general, 64% of the respondents felt that the annotation feature was useful. With regards to the interface design, 86% of the respondents agreed that the use of the yellow sticker icon to indicate annotations was helpful.
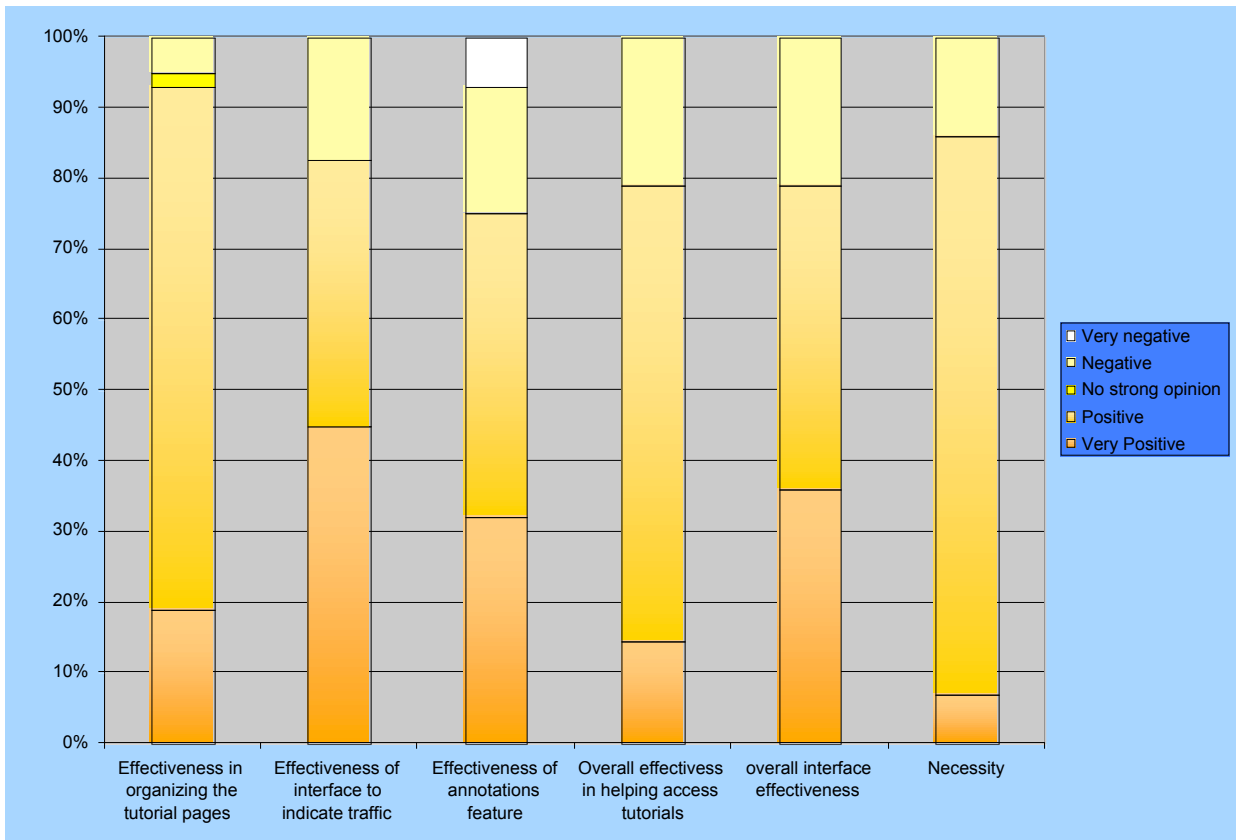
30% of the respondents weren't interested in the sharing of annotations between the users of the group. The rest agreed to at least some level of sharing of annotations.

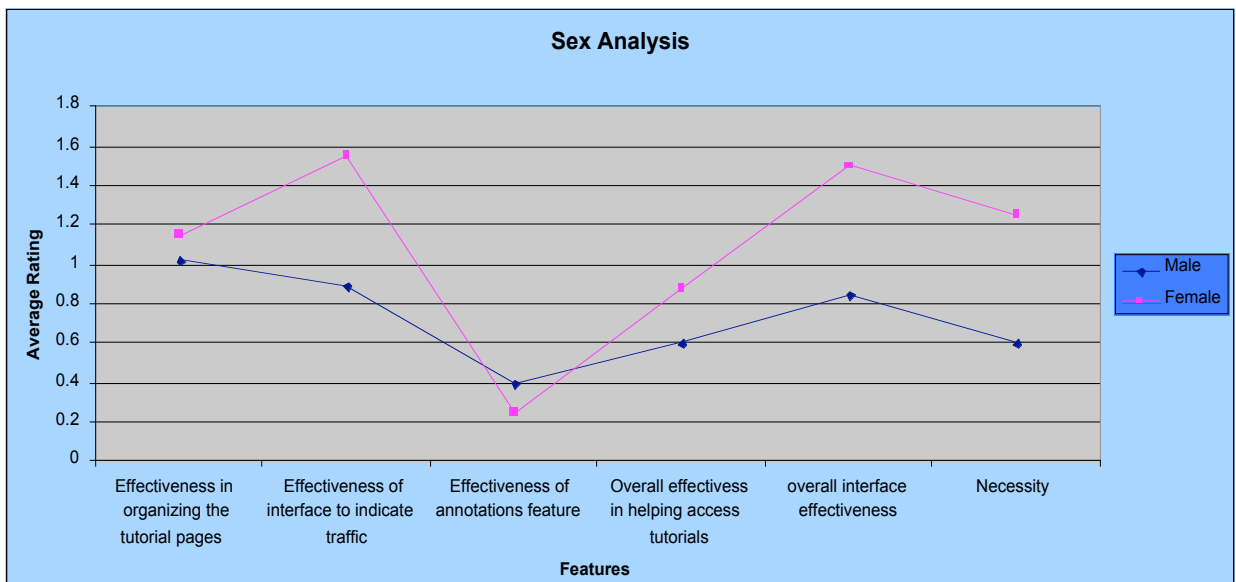### 3.2.4 Analysis of the answers to the open ended question

The open ended question gave the respondents the opportunity to add any comments, and suggestions, and voice their concerns if any about the system in their own words.

All of the respondents left some feedback. A few felt that the interface was overwhelming to start with and had a learning curve, but in general found it very helpful. Suggestions were made to do away with the human figure icon to indicate user traffic, and to use meters instead of colors to indicate level of traffic.
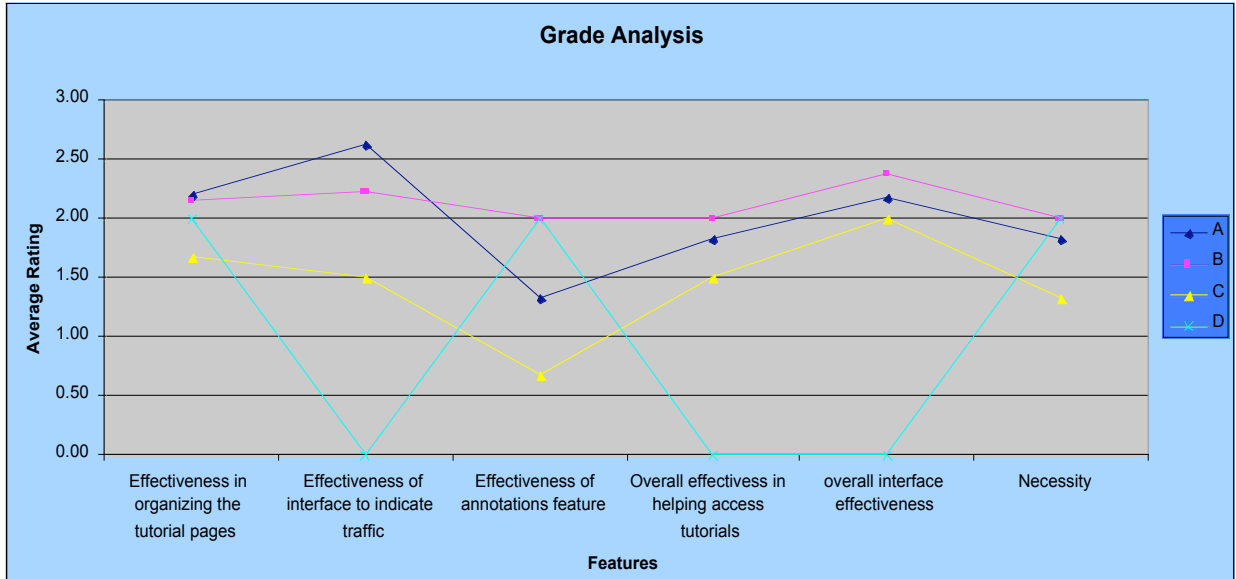
4. Analysis Charts

Legend:
- Very negative
- Negative
- No strong opinion
- Positive
- Very Positive

X-axis categories: Effectiveness in organizing the tutorial pages | Effectiveness of interface to indicate traffic | Effectiveness of annotations feature | Overall effectivess in helping access tutorials | overall interface effectiveness | Necessity

Effectiveness of each feature

Sex Analysis

Y-axis: Average Rating

X-axis: Features — Effectiveness in organizing the tutorial pages | Effectiveness of interface to indicate traffic | Effectiveness of annotations feature | Overall effectivess in helping access tutorials | overall interface effectiveness | Necessity
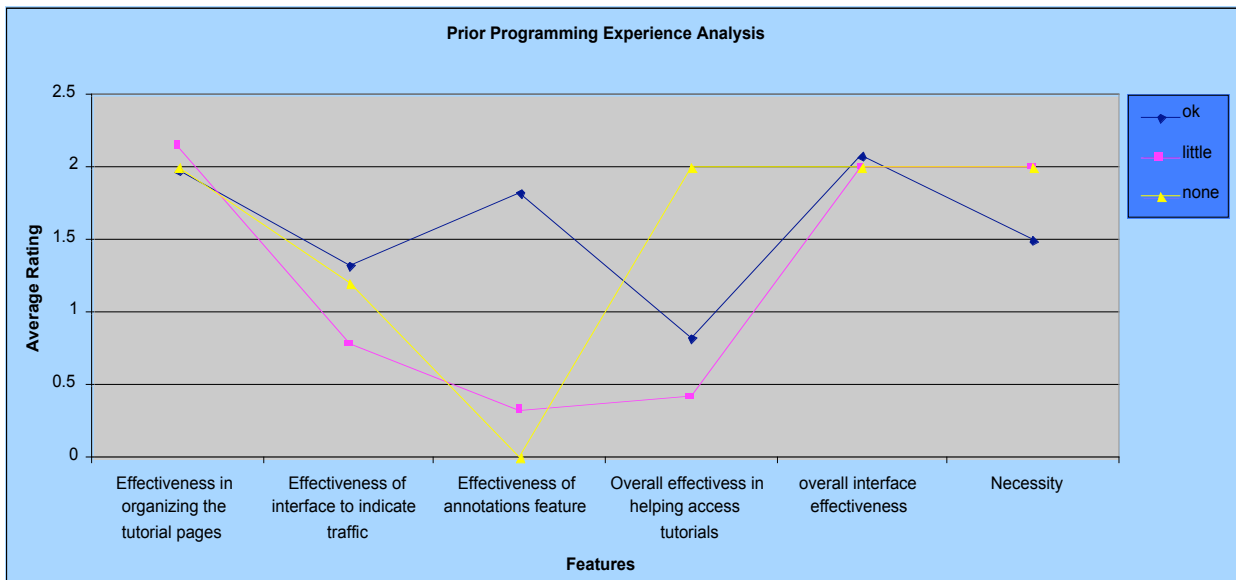
Legend: Male, Female

Analysis of feature effectiveness with subjects divided based on sex

Analysis of feature effectiveness with subjects divided based on academic performance*

* Only 1 student with grade D, hence the graph is erratic for Grade = D

Analysis of feature effectiveness with subjects divided based on prior programming experience

5. Conclusions and future work

The new implementation of the system is now flexible enough and conducive to further research on the system.

Based on the user survey results, we can conclude that the system is effective and we have made improvements over the original system in a positive way.

Many features may be added to this system to make it better.

In the future we need to explore alternative methods of indicating traffic like using meters to indicate traffic, and evaluate them to see if they are more effective.

We need to expand on the idea of annotations. Users currently cannot read other users' annotations. We may provide the users with a facility to do it, and in addition also enable users to indicate some of their annotations as private so that their privacy is maintained.

Another useful feature may be adaptive recommendation system to recommend most relevant pages to the user. We may maintain a representation of the user knowledge within the system and use it to make recommendations to the user of pages that would be most useful to him/her given his/her current level of knowledge and goals.

5.References

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4. Henze N. and Nejdl W.(2002), "Knowledge Modeling for Open Adaptive Hypermedia". *In Proceedings of the 2nd International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems.*