The Carolina Health Informatics Program (CHIP) is a new program at the University of North Carolina at Chapel Hill that conducts research and training in health sciences by applying informatics approaches. The CHIP “Faculty, Scholars and Researchers” webpage (http://chip.unc.edu/faculty-scholars-researchers/) provides information about the CHIP faculty and researchers. The goal of this project is to enhance the webpage by adding dynamically updatable information about each member’s current research. The goal was achieved by retrieving the information from Google Scholar and PubMed databases by executing the client-side and server-side code written in JavaScript/JQuery, PHP, CCS, and Ajax. A usability study was performed to assess the enhanced webpage. Based on the usability study findings, the prototype system was improved and further suggestions for improvements were proposed. The usability study demonstrated that the developed prototype greatly enhanced the usefulness of the website and helped to achieve CHIP’s goal to provide easy access to the current research information for each faculty member.

Headings:

Usability Study

Google Scholar

PubMed

Entrez Programming Utilities
CAROLINA HEALTH INFORMATICS PROGRAM WEBSITE OVERHAUL TO IMPROVE USABILITY AND INFORMATION ACCESS

by
Evgeniia Kazymova

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Approved by

_______________________________________
Javed Mostafa
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Introduction

Carolina Health Informatics Program (CHIP) is a new program at the University of North Carolina at Chapel Hill that conducts research and training in health sciences by applying informatics approaches. The major topics for research include genetics, clinical care, and population health. Currently more than 40 faculty and staff are involved in research and training within the program. The CHIP faculty members come from different schools and institutions across the university campus and beyond: School of Medicine, Gillings School of Global Public Health, School of Information and Library Science, Department of Computer Science, Health Science Library, Renaissance Computing Institution etc. Such diversity makes it difficult to find information about current research in health informatics performed by the CHIP faculty. CHIP is looking for the best methods to facilitate access to CHIP faculty members’ research.

The CHIP “Faculty, Scholars and Researchers” webpage (http://chip.unc.edu/faculty-scholars-researchers/) provides information about CHIP faculty and researchers. Currently, the webpage presents only limited information about each CHIP member (name, degree, position, and a photograph). The CHIP webpage needs to be enriched with more detailed and useful information about each member of the program. A tool that would help other researchers and students to get a quick way to see the most resent and most popular publications for each researcher would greatly enhance the usefulness of the website. Such a tool would help to get an idea about members’ main interests and current work.

We suggest enhancing the website by adding dynamically updatable information about each member’s current research (e.g. references to the five most recent articles from Google Scholar and PubMed). We hypothesize that this new tool would greatly enhance the usefulness of the website and help to achieve CHIP’s goal of providing easy access to current research information.
**Literature Review**

The goal of this project is to enhance the usefulness of the CHIP faculty webpage. Therefore, an important part of the project is to assess usability of the website after the changes are implemented. In this literature review we compare and contrast different models developed to assess usability of websites and the factors they take into account.

One major tool in evaluating websites is usability testing [1,2]. There are many factors that affect website usability. The human-computer interaction and the software engineering communities accumulated all those factors into several models [3,4]. The two most widely used models are Nielsen’s model (1993) and ISO 9241-11 model (1998).

Nielsen’s model developed in 1993 includes five factors that allow evaluating usability in general: learnability, efficiency, memorability, low error rate and subjective satisfaction [5,6]. Nielsen defines those factors as follows:

1) **Learnability**: How easy is it for users to accomplish basic tasks the first time they encounter the design?
2) **Efficiency**: Once users have learned the design, how quickly can they perform tasks?
3) **Memorability**: When users return to the design after a period of not using it, how easily can they reestablish proficiency?
4) **Errors**: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
5) **Satisfaction**: How pleasant is it to use the design?

The International Organization of Standardization (ISO) is a system for worldwide standardization [7]. This organization has developed several standards to specify and measure software usability. One of them is ISO 9241. Part 11 of this standard includes factors for assessing website usability similar to Nielsen’s model: effectiveness, efficiency, and satisfaction [8]. According to the standard the definitions for each factor
are as follows:

1) **Effectiveness** refers to the completeness with which users achieve specified goals;
2) **Efficiency** refers to the resources used in completing a task;
3) **Satisfaction** reveals positive attitudes toward using the system (ISO, 1998).

Dubey reviewed usability definitions and their decomposition into various characteristics [4]. He identified 152 characteristics of usability presented in different models. According to the results of Dubey’s study, efficiency, learnability and satisfaction are the most frequent characteristics. So they have the most impact on software system and should be taken into account during usability decision-making.

The two models discussed above (Nielsen’s and ISO 9241-11) are very general and mostly focused on a system’s characteristics [5,8]. More specific examples of evaluating the usability of information services websites are available. For example, Tsakonas [9] asserts that the usability criteria can be adopted based on a website specification. He suggests that for a library-related website the following usability criteria are most important:

1) **Ease of use** refers to how easy it is to use all functions provided by the system.
2) **Aesthetic appearance** of the system may influence the users affectively.
3) **Navigation** is the ease of navigation through the system.
4) **Terminology** refers to the comprehensibility of terms and phrases used to describe functions or content.
5) **Learnability** is an intrinsic property of usable systems that delivers users from the process of self-instruction or attending structured courses.

In addition, Tsakonas claims that the content characteristics of the system also affect user-system interaction. According to Tsakonas, the interaction between a user and system’s content can be defined as “usefulness”. The study showed that usefulness and usability are related and should be measured in parallel. Tsakonas suggests five major characteristics of usefulness that can be measured:

1) **Relevance** denotes how (topically) the content corresponds to the work task.
2) **Format** is a resource attribute that connects with the user’s work practice and/or the available technological infrastructure.
3) **Reliability** investigates how credible the resource is and how well it satisfies
present and future aspects of the work task.

4) **Level** refers to the various representations of information provided, such as abstracts, full text etc.

5) **Timeliness** investigates how current the information resource is and how well it will satisfy the information need.

Another study by Yang [10] developed the methods to measure the quality of information service websites. He proposed six dimensions to access the quality of a website; usefulness and usability are among those dimensions. According to Yang, usefulness is based on the value, reliability, currency, and accuracy of information. The definitions of these characteristics are as follows:

1) **Information value** is concerned with relevancy and clearness.

2) **Information reliability** refers to its accuracy, dependability, and consistency.

3) **Information currency** is concerned with information timeliness and continuous update.

4) **Information accuracy** describes the degree to which the system information is free of error.

In regard to usability assessment Yang named the following characteristics: content layout and classification, website structure, user interface, website appearance and visual design, intuitiveness, readability/comprehension/ clarity, search facilities, and ease of navigation.

To summarize, there are many factors that can be measured in a usability/usefulness study of a website. The importance of these factors depends on the specific website, its mission, and its users [4]. Therefore, it is important to prioritize the usability and usefulness factors to be used in a usability study. For a website like “Carolina Health Informatics,” the goal of which is to improve information access, the most relevant usability measurements would be overall satisfaction, system usefulness, information quality, and interface quality. The next section will describe the approach to the implementation of the system and the assessment of its usability and usefulness.
Methods

The goal of the project is to improve the usability and usefulness of the CHIP website. In particular, the new website design should be improved in such a way that any faculty member or student could easily find information about current research in health informatics performed by a particular CHIP faculty member.

The improvement of the CHIP website design was performed based on a software prototyping methodology [11]. The process of prototyping involved four steps:

1) Developing requirements for the system;
2) Implementing a prototype system;
3) Performing usability testing;
4) Revising and enhancing the prototype.

The requirements included the detailed description of the system to be developed. For example, it included the description of appearance of the prototype system, the technical functionality (what happens if a user clicks a link, or closes a window), and the information it would contain.

As the second step, the prototype system was implemented based on the defined requirements from the first step. The following technologies were used to develop the system: a) JavaScript/JQuery was used to create new pop-up windows that would contain the information about the most recent articles for each CHIP faculty member, b) HTML DOM parser and PubMed Application Programing Interface (API) were used to query the corresponding publicly available databases to retrieve the most recent articles for each faculty member, c) PHP, Ajax, and CSS were used to improve the appearance of the website.

A small usability study was performed to evaluate the prototype system. A total of 8 users, SILS students and UNC employee, participated in the usability study.
The usability study included the following stages: planning the usability study (creating tasks for the users, developing questionnaires, preparing the technologies to perform the study, finding the users etc.), conducting the usability study and analyzing the results. Quantitative data were collected during the usability study to measure the usability and usefulness of the proposed system. The following factors were used to assess usability: overall satisfaction, system usefulness, information quality, and interface quality. A set of open-ended and 7-point Likert-type scales anchored by “7” as “strongly agree” to “1” being “strongly disagree” questions was developed to measure each factor. Each user performed six tasks and then answered the questions. The usability study was performed at a computer laboratory at the School of Information and Library Science; the users’ screen activity and voice were recorded during the completion of the tasks. Each user was asked to think aloud while working on the tasks. Two types of information were collected during the usability study: think aloud protocols and interviews.
Developing a Prototype System

Functional Requirements

The original webpage “Faculty, scholars, and researchers” is located under the URL http://chip.unc.edu/faculty-scholars-researchers/. This webpage is planned to be enhanced by adding dynamically updatable information for each CHIP member’s current publications. The functional requirements for the prototype system are listed below.

1) A small window should pop up in the left corner of the web page “Faculty, scholars and researches” when a user clicks with a mouse over the name or the photograph of the CHIP faculty.

2) The user should be able to close the window by clicking the “close” sign in the corner of the window. If the user does not close the window and clicks on a different faculty member, the current window should close and a new window should open.

3) The window should include the phrase “Most recent publications by [name of the faculty member]” and the titles for the 1-5 most recent articles from Google Scholar or PubMed where the faculty is one of the authors.

4) The size of the window should be that it does not cover the whole screen and the text should still be readable.

5) The recent articles should be updated automatically. The information on the articles should be loaded automatically directly from PubMed or Google Scholar server when a pop up window is opened.

6) Each article should include a link to the actual article in the Internet. Also, there should be a link to the PubMed or Google Scholar search results by the author’s name.
Technologies Used to Enhance the Webpage

Since the CHIP faculty members are very diverse, two databases, PubMed and Google Scholar, are used to retrieve recent research publications. PubMed is used to get the publications for the faculty members related to medicine, and Google Scholar is used to get the publications for the faculty members related to Computer Science, Library Science or Information Science. NCBI’s Entrez Programming Utilities (the application programing interface (API) to the Entrez system of databases at NCBI) is used to get data from PubMed. Google Scholar does not provide any API, therefore one option to get articles from its server is to use PHP programming language to get the HTML source code and parse it by using different PHP functions. Finally, to open a pop up window on a user’s click, JQuery is utilized. The program is optimized for Mozilla Firefox web browser.

Description of the Program Code Functionality

**Step 1:** All faculty members are listed in a two-column table on the webpage. The cells on the left side of the table contain a photo; the cells on the right contain basic information about the faculty member (Fig. 1).

![Partial screenshot of “Faculty, scholars and researchers” CHIP webpage](image)
The grey area and the photograph will be a place to click to open a pop up window. In order to recognize which faculty member was clicked on, we need to assign a unique identifier for each cell in the table. Faculty last name is used as a unique identifier for each person. Class tooltip allows opening a help message when the mouse cursor hovers over the faculty cell.

```html
<td id = "Dr.A" class = "tooltip">
<img src="http://chip.unc.edu/files/2014/02/DrA.jpg" alt="" />
</td>
<td id = "Dr.A" class = "tooltip"><strong>Dr.A</strong>, PhD</p>
<p>Professor at the <a href="http://www.cs.unc.edu/cms target="_blank">Department of Computer Science</a> and</p>
<p>Director of the <a href="http://www.renci.org/ target="_blank">Renaissance Computing Institute (RENCI)</a></p>
</td>

Step 2. The code below selects all tags with class=tooltip to show up a message on mouse over.

```javascript
$(".tooltip").attr('title', 'Click to see recent articles');
```

Step 3. The variable id stores the name of the attribute that was clicked. The variable gs = FALSE means that PubMed is used for searching. The value of this variable is changed to TRUE in case when Google Scholar is used for searching the publications.

```javascript
$(".tooltip").click(function(){
    var id = $(this).attr('id');
    var gs = FALSE;
```

Step 4. The switch statement defines the search term and the title to be used inside the pop up window based on the attribute value received upon user click. The title contains the faculty name and the database used for searching. Also it changes the value of gs variable to TRUE if Google Scholar should be used for searching. The switch statement evaluates 48 expressions, one for each faculty member. The variable gs is set to TRUE for faculty members whose publications are better represented in Google Scholar than in PubMed.

```javascript
switch (id) {
    case "Dr.A":
        var search_term = "A%2BB";
        gs = true;
        var window_title = "<b>Most recent articles by Dr.A, PhD " + "from Google Scholar</b>";
        break;
...
Step 5. The conditional statement specifies the block to be executed based on the value of gs. If gs=true, the block of the code that retrieves the articles from Google Scholar is executed. Otherwise, PubMed is used for retrieving the most recent articles for a faculty member.

Since two different databases are used for retrieving the articles, two different strategies are applied. Google Scholar doesn’t have any application programming interface. Therefore, the search term is being passed to the PHP code (google_scholar_results.php file stored on server) which retrieves the articles from Google Scholar by creating a link, and then receiving and parsing the content of Google Scholar webpage. On the other hand, PubMed provides E-Utilities that can be used to retrieve the articles. These two strategies will be explained in more detail in the next steps.

Step 6. A separate PHP code retrieves the articles from Google Scholar. First we need to check whether the search term was sent from chip_faculty.html to google_scholar_results.php. If the search term was sent, it stores the search term in $search_term variable.

```
$search_term = (isset($_GET['search_term']) ? $_GET['search_term'] : null);
```

Then we need to create a link to get the webpage that contains 5 recent articles by a faculty member.

```
$html = "http://scholar.google.com/scholar?hl=en&as_sdt=1,34&as_vis=1&q=author:%22" . $search_term . "%22&scisbd=1&num=5";
```

The variable $content gets the HTML source code of the webpage under the link built above by using PHP function file_get_html.

```
$content = file_get_html($html);
```

Next we need to parse the content to get the title, the list of authors, the journal and the date, using the HTML DOM parser. This tool was chosen because it’s written in PHP5 and provides an easy way to handle HTML elements. In order to use the HTML DOM parser, we need to download simple_html_dom.php from http://sourceforge.net/projects/simplehtmldom/files/latest/download website and include this file into the code.
The code below searches the div element with class name gs_ri and writes the content of this div element into variable $article. Then two foreach loops go through the content of the $article to find and print out on the screen the title and the list of authors.

```php
foreach($content->find('div.gs_ri') as $article) {
    foreach($article->find('h3') as $title) {
        foreach($title->find('a') as $a) {
            $a = html_entity_decode($a);
            $a = preg_replace("/\&[a-zA-Z0-9]+;/i", "", $a);
            $a = str_replace("< i>", "", $a);
            echo $a;
            echo "<br>";
        }
    }
    foreach($article->find('div[class=gs_a]') as $author) {
        echo $author;
        echo "<br>";
    }
}
```

Although the HTML DOM parser is a very convenient tool to extract the information from a source code, its major disadvantage is that if Google Scholar changes the name of the div tags then the code has to be changed accordingly.

**Step 7.** We use the Entrez Programming Utilities (E-utilities) to retrieve the articles from PubMed. E-utilities are a set of eight server-side programs that provide a stable interface to the Entrez query and database system at the National Center for Biotechnology Information (NCBI). Two E-utilities, ESearch and ESummary, are used to get the title of the articles, the list of authors, the journal and the publication date for each article. ESearch is used to get the list of UIDs matching a text query, web environment string (web_env) and query key (query_key). The web_env parameter specifies the Web Environment that contains the UID list to be provided as input to ESummary. The query_key integer specifies which of the UID lists attached to the given Web Environment and is used as input to ESummary. The code below creates a link to get data from PubMed server in json format. JQuery get function parses the json file to retrieve the variables in order to pass them to ESummary.

```php
var url_search =
```
All parameters extracted from ESearch are passed inside the link to ESummary to get data for each faculty member.

```javascript
    'db=pubmed&query_key=' + query_key + '&WebEnv=' + web_env+'&retmode=json&retmax=5';
```

The received data in `json` format is parsed to get the title, the list of authors, the journal and the publication date. The full version of the code with comments is in Appendix A.

**Step 8.** Next we print results in a pop up window by using JQuery `window.open` function. The results are printed starting from the most recent articles. However, in some browsers such as Chrome and Safari the most recent article goes in the bottom due to the browser specific printing feature.

The window has a menu bar to allow users to open each article or see all articles by this author from the PubMed or Google Scholar search results in the same window. Then the menu bar allows going back to the list of recent articles. The user can also make the window full screen or close it. If the user forgets to close the window and clicks with
the mouse outside of the window, the window will close automatically. Separate css file `pop_up_window.css` defines the style of the pop up window (Appendix A).

The flowchart in Fig.2 demonstrates the work of the code.

```
chip_facuty.html

On user click switch statement defines the search term and database

Google Scholar == true

Search in PubMed by using ESearch and ESummary
pop_up_window.css

Print results in pop up window

Search in Google Scholar by parsing HTML code
google_scholar_results.php
simple_html_dom.php
pop_up_window_css.css

Print results in pop up window
```

Fig.2 Flowchart of the programming code

Two screenshots in Fig.3 and 4 show the pop up window with Google Scholar and PubMed search results.
Fig. 3 Screenshot of pop up window with Google Scholar search results for Dr. A

Fig. 4 Screenshot of pop up window with PubMed search results for Dr. B
Usability Study Results

Design of the Usability Study

A Usability study was conducted in order to assess the enhanced “Faculty, scholars and researchers” webpage. The usability study was approved by IRB (#15-0104). The study was performed in a reserved room at the School of Information and Library Science. First, each participant signed a consent form. Then the participants of the study were asked to complete the pre-test questionnaire, six search tasks, the exit questionnaire, and the Computer System Usability Questionnaire. No personally identifiable information was collected during the survey. Three-digit identification numbers were assigned to participants in order to distinguish them from each other. Thinking aloud was encouraged while working on the tasks. The on-screen activity and the voice of the participant during task completion were recorded. All collected data were stored in an encrypted folder on a password-protected computer. A total of eight people participated in the usability study. It took approximately 30 minutes to complete the whole usability test for each participant.

Entry Questionnaire

The entry questionnaire contained 5 questions (Appendix D). The participants in the usability study were: three SILS graduate students, one UNC undergraduate student, three UNC employees, and a software developer. Three of the eight participants had never visited the Carolina Health Informatics Program website prior to this study. Five participants have had experience using PubMed; six participants had experience using Google Scholar. Four participants use Mozilla
Firefox for browsing the Internet; two people use Safari, and two people use Chrome.

**Usability Tasks**

The usability study consisted of six tasks (Appendix C). The main goal of the first task was 1) to let a user explore the “Faculty, scholars, and researchers” webpage and 2) to recognize how to open a pop up window with the faculty member’s most recent articles. They had to scroll up and down to see all faculty members presented on this webpage, to recognize the order in which they are listed and the amount of information for each faculty member on the webpage. All users very quickly completed this part of the task; however the next part was confusing for some users. All participants quickly realized that the faculty members are listed in alphabetical order so they easily found a specific faculty member in the long list of other faculty members. Two participants used a browser search field to find Dr. B. In order to find the most recent articles by Dr. B, five of eight participants attempted to click the link that leads to a department website where people work, instead of the appropriate clickable area. Other users by an occasional random click realized how to open a pop up window. None of the participants read the help message “Click here to see recent articles” when the mouse went over the clickable area. This message appears with a short delay. The participants moved the mouse fast enough so the message didn’t have time to appear on the screen.

The second task was to find the most recent article by Dr. B. All users very quickly realized that the articles are listed in chronological order so they easily found the most recent one, which was on the top of list. The third task was asking to find all articles by Dr. B. All participants without any problem found the link “See all articles” in the pop up window which goes directly to the PubMed website to see the whole search results.

The main goal of tasks 4 and 5 was to let users work with pop up windows in order to find an appropriate faculty member’s research interests based on publications that appear in the pop up window. Also these two tasks explicitly demonstrate the situations in which the pop up windows with recent publications might be used. Task 4 was to find a faculty member who does research in data visualization; task 5 was to identify a faculty member who has experience in using PROMIS pediatric scale in his research. All users used the same strategy to complete these two tasks. To complete task
4, all participants opened a pop up window only for faculty who related to information science or library science and then skimmed quickly the recent publication by the selected faculty member to get an idea of what kind of research he or she does. In the same way task 5 prompted the participants to search among people related to medicine. Two participants attempted to use the browser search field to find a pediatrician; however, that wasn’t helpful because the PROMIS pediatric scale might be used by any faculty, not only by pediatricians. These two tasks were the most time consuming for all participants because they had to open a pop up window for each faculty member in order to find needed information. One of the participants wanted to use the website search field; however this method will not show faculty articles. In the end, all users successfully completed tasks 4 and 5 within different time frames.

Finally, task 6 was to test the pop up windows that don’t contain any publications. Participants were asked to find at least one person for whom no recent articles are retrieved from PubMed or Google Scholar. All participants used their experience from working on the previous tasks. Two users occasionally found people who don’t have any publications while doing tasks 4 and 5. They directly went to that person to show the empty pop up window. Others were guessing who might not have any publications and checked the pop up window for them. Eventually they all found at least one person with no publications at the moment when this task was performed.

**Exit Questionnaire**

The exit questionnaire has twelve questions and is designed to obtain participants’ opinion on the current prototype and further improvement of the webpage (Appendix E). Seven participants said that the size of the text in the pop up window was normal; one said that it was too small. Five participants thought that the size of the pop up window was normal; the other three participants thought that it was too small. Almost all users except one agreed that initial location (upper-left corner) works well. Six of the eight participants thought that a pop up window works well to show most recent articles; however, two people preferred to see the results in a new tab. Their argument for the new tab was that when one needs to compare research by different faculty it’s better to have several tabs opened to be able to switch between them. All people agreed that the amount
of information in the pop up window (up to five recent articles) is enough to complete the tasks. None of the participants noticed any articles shown in a pop up window that didn’t belong to a faculty member who was clicked on. Two usability tasks were asking to find a faculty member with certain research interests, and five participants thought that the most recent articles reflected the faculty’s current research interests. Two people thought that the articles where the faculty member is the last author better demonstrate the faculty’s current research interests. One participant answered that “It can be hard to tell interest from article titles, especially because several articles may stem from the same research (which might not be the researcher's focus)”. Even though participants have very different opinions about this question, we believe that most of the time the most recent articles reflect the current faculty’s research focus. None of the participants noticed any lag between when they performed a click and the pop up window popped up.

Finally, most users would allow opening pop up windows on this website if they opened this webpage on their computer.

**Computer System Usability Questionnaire**

The Computer System Usability Questionnaire (CSUQ) (http://hcibib.org/perlman/question.cgi) developed by Lewis, J. R. in 1995 was used to evaluate the participants’ satisfaction with the webpage. The test contains 19 questions. The questions are listed in Appendix F. The extremes of the 7-item Likert scale are labeled “Strongly Agree” and “Strongly Disagree”. “Strongly Agree” corresponds to 7 and “Strongly Disagree” corresponds to 1. Question 9 (“The system gives error messages that clearly tell me how to fix problems”) was excluded from the survey because the system doesn’t provide any error messages. The table below contains the participants’ answers to 18 questions.

Four scores were calculated from the responses to the CSUQ: the overall satisfaction score (OVERALL), system usefulness (SYSUSE), information quality (INFQUAL) and interface quality (ITERQUAL). Each score is an average of the corresponding items: OVERALL is an average of items from 1 through 19, the SYSUSE is an average of items from an average of items from 1 through 8, the INFQUAL is an average of items from 10 through 15, the ITERQUAL is an average of items from 16
through 18. Three users put “not applicable” for question 11. Those responses were excluded from the average. Table 2 shows the averages for each user for each score. Higher scores are better than lower scores due to the anchors used in 7-point scale.

Table 1. Participants’ responses to CSUQ

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<td>6</td>
</tr>
<tr>
<td>User 004</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>User 005</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>User 006</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>User 007</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>User 008</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2. The average score for each user for each scale

<table>
<thead>
<tr>
<th></th>
<th>OVERALL</th>
<th>SYSUSE</th>
<th>INFOQUAL</th>
<th>INTERQUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 001</td>
<td>6.4</td>
<td>6.5</td>
<td>6.5</td>
<td>6.0</td>
</tr>
<tr>
<td>User 002</td>
<td>1.3</td>
<td>1.5</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>User 003</td>
<td>6.0</td>
<td>5.9</td>
<td>6.2</td>
<td>6.0</td>
</tr>
<tr>
<td>User 004</td>
<td>5.8</td>
<td>6.0</td>
<td>5.2</td>
<td>6.3</td>
</tr>
<tr>
<td>User 005</td>
<td>6.3</td>
<td>6.8</td>
<td>5.3</td>
<td>7.0</td>
</tr>
<tr>
<td>User 006</td>
<td>6.6</td>
<td>6.6</td>
<td>6.6</td>
<td>6.7</td>
</tr>
<tr>
<td>User 007</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>User 008</td>
<td>4.9</td>
<td>4.0</td>
<td>5.3</td>
<td>6.0</td>
</tr>
<tr>
<td>Min</td>
<td>1.3</td>
<td>1.5</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Max</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Mean</td>
<td>5.5</td>
<td>5.5</td>
<td>5.4</td>
<td>5.8</td>
</tr>
<tr>
<td>SD</td>
<td>1.8</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Based on the averages listed in Table 2 almost all users were satisfied with the system in terms of overall satisfaction, system usefulness, information quality, and interface quality; the scores ranged from 4.0 through 7.0. However user 002 wasn’t satisfied with the system because his averages are very low.

The minimum, the maximum values, the mean and the standard deviation were calculated for each scale (Table 2). The minimum and maximum values indicate that the user satisfaction of the system ranges from very low 1.0 to very high 7.0. The interface quality scale (INTERQUAL) received the highest average value 5.8. The information
quality (INFQUAL) received the lowest average value 5.4 among other scales. The overall satisfaction (OVERALL) and system usefulness (SYSUSE) have the same average value 5.5. However the difference between the averages for all scales are not small and do not exceed 0.3 units. Standard deviation for all scales was in the range 1.8 – 1.9.

Also the participants were asked to list some positive and negative aspects of the prototype system. Some users’ responses are listed in Table 3.

Table 3. Users’ positive and negative comments about the system

<table>
<thead>
<tr>
<th>Positive comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Easy to find all articles from PubMed or Google”.</td>
</tr>
<tr>
<td>“The organization is very clear”.</td>
</tr>
<tr>
<td>“I am able to find all the information I need”.</td>
</tr>
<tr>
<td>“The system provides very fast result for my request”.</td>
</tr>
<tr>
<td>“Attractive interface”.</td>
</tr>
<tr>
<td>“Easy transition from CHIP site to PubMed”.</td>
</tr>
<tr>
<td>“The system is pretty intuitive”.</td>
</tr>
<tr>
<td>“Easy to use”.</td>
</tr>
<tr>
<td>“Organization is clear and provides the ability to follow quickly”.</td>
</tr>
<tr>
<td>“Ease at accessing articles”.</td>
</tr>
<tr>
<td>“Easy to use, good idea”.</td>
</tr>
<tr>
<td>Negative comments:</td>
</tr>
<tr>
<td>“Not all recent articles are displayed”.</td>
</tr>
<tr>
<td>“Needs to unblock popup windows”.</td>
</tr>
<tr>
<td>“Could not easily recognize the active part around the names for a click. I wanted to click on the name”.</td>
</tr>
<tr>
<td>“I wanted to do the search in the special place on the top right corner”.</td>
</tr>
<tr>
<td>“The pop up window is not very easy to use”.</td>
</tr>
<tr>
<td>“I would like to do some search instead of clicking one by one”.</td>
</tr>
<tr>
<td>“Interests must be deduced from academic article titles (full of jargon)”.</td>
</tr>
<tr>
<td>“I didn’t know where to click to access information (cursor didn't change)”.</td>
</tr>
<tr>
<td>“Popup window either closed automatically or was lost behind current window”</td>
</tr>
<tr>
<td>“Doesn't have enough information about the people, specifically what departments they work for”.</td>
</tr>
<tr>
<td>“Inability to search on the page for topics”.</td>
</tr>
<tr>
<td>“Not sure how long it might take some people to scroll over photo and realize you could access articles by clicking on it”</td>
</tr>
</tbody>
</table>
To summarize, based on users’ positive comments the system is easy to use, intuitive, and attractive. Major problems with the system are that the pop up window might be blocked and not all users would allow opening it, and that it’s hard to recognize the clickable area to open a pop up window.
Prototype Revision

The study participants provided helpful feedback regarding the usability of the “Faculty, scholars and researchers” webpage. The results of the study suggest that the webpage is usable. Based on users’ comments and work on the task one minor improvement can be done to make it more usable, namely changing the arrow into another symbol when the user moves over the clickable area or adding a link “See recent articles” for each faculty member. The first option was chosen because it can be implemented with more efficient code. An example of a code below changes the cursor symbol on mouse over the clickable area.

```javascript
$('.tooltip').css('cursor', 'pointer');
```
Discussion

Future Work

The results of the usability study suggest that the system is usable; however some future work should be done to improve the system. The first improvement would be to make the system fully functional in any browser because based on entry questionnaire people use different browsers. Currently the system is fully functional in Mozilla Firefox version 36.0.1; however, some functions do not work as intended in other browsers. Table 4 summarizes some browser-related issues; other issues might also be found. Opera and Internet Explorer were not tested because none of the usability study participants use Opera or Internet Explorer.

Table 4. Non-Firefox browser issues

<table>
<thead>
<tr>
<th>Browser/Issues</th>
<th>Printing articles in pop up window</th>
<th>Toolbar in pop up window</th>
<th>Pop up window</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chrome</td>
<td>Articles are printed in reverse order in pop up window with PubMed search results</td>
<td>Toolbar isn’t supported in Chrome</td>
<td>-</td>
</tr>
<tr>
<td>Safari</td>
<td>Articles are printed in reverse order in pop up window with PubMed search results</td>
<td>-</td>
<td>Pop up window with Google Scholar search results is not opening</td>
</tr>
</tbody>
</table>

Another suggestion for future work would be to use CSS to create a pop up window. This solution would help to avoid a problem with blocked pop up windows.

The Next idea for future work is related to the system design. The current version of the code requests articles from PubMed or Google Scholar each time a user clicks on the clickable area. The major issue with this solution is that if PubMed
receives three requests within one second from the same IP address it might block this address. The same may happen with Google Scholar. To avoid this issue, the data needs to be stored in a database on the server and when a user performs a click, the system requests the data from this database. The database can be updated once a week in order to store the most recent articles in it. This solution with the database might be a good alternative to the current solution.

Finally, making the system accessible for people with disabilities might improve the current system. Also, the ability of the system to work on different electronic devices would greatly enhance its usefulness.

**Conclusion**

The goal of the project was to enhance the CHIP website, in particular “Faculty, scholars and researchers” webpage, by adding dynamically updatable information about each member’s current research. This goal was achieved by using different technologies such as JavaScript/JQuery, PHP, CCS, Ajax and public databases such as Google Scholar and PubMed. A usability study was performed to assess the enhanced webpage. Based on the usability study findings, the prototype system was improved and further suggestions for improvements were proposed. The usability study demonstrated that the developed tool greatly enhanced the usefulness of the website and helped to achieve CHIP’s goal to provide easy access to current research information for each faculty member.
Works Cited


Appendix A. Programming Code

Presented below is the programming code for three files: *chip_faculty.html*, *google_scholar_results.php*, *popup_window.css*.

*chip_faculty.html*

```html
<!--
The script below opens a new window with 1-5 most recent articles for each faculty member on mouse click. Also see google_scholar_results.php for additional script retrieving search results from Google Scholar (variable 'result')-->

<script type="text/javascript"
    src="http://ajax.googleapis.com/ajax/libs/jquery/1.4.2/jquery.min.js">
</script>
<script type="text/javascript">
$(document).ready(function() {
    //select all tags with class=tooltip to show up a help message on mouse over
    $('.tooltip').attr('title', 'Click to see recent articles');
    //change the cursor arrow to pointer to indicate the clickable area
    $('.tooltip').css('cursor', 'pointer');
    $('.tooltip').click(function() {
        //get the value of the clicked element
        var id = $(this).attr('id');
        //if gs = false PubMed will be used for searching otherwise Google Scholar
        var gs = false;
        //define search term and the title for a new window based on the attribute value
        switch (id) {
            case "Dr.A":
                var search_term = "A%2BB"
                gs = true;
                var window_title = "<b>Most recent articles by Dr. A, PhD "
                + "from Google Scholar</b>";
                break;
            ...
            case "Dr.Z":
                var search_term = "Z%2Z"
                var window_title = "<b>Most recent articles by Dr. Z, PhD "
                + "from Google Scholar</b>";
                gs = true;
                break;
        }
    });

    <!-- google_scholar_results.php -->
    <!-- popup_window.css -->
</script>
```
if (gs == true) {
    //get function sends search term to
google_scholar_results.php file
    url = "google_scholar_results.php?search_term=" +
    search_term + "&database=gs";
    $.get(url, function(gs_result) {
        var results_window = window.open
        ("about:blank", "", "width=650, height=350,
        scrollbars=yes, " + "fullscreen=no,
        toolbar=yes, menubar=yes");

        //add a title to a pop-up window
        results_window.document.write
        ("<head><title>Search Results</title></head>");

        //display the title and results from Google
        Scholar in a new window
        results_window.document.write
        ('<strong>' + window_title + '</strong>');

        //create a search link to see all articles
        //Dr. G published most articles in the end of
        //90s
        //so her search link is different from other
        //faculty
        if (search_term == "G%2GG") {
            results_window.document.write
            ("<p><a href =
                http://scholar.google.com/scholar?q=autho
                r%3A%22" + search_term
                +"%22&hl=en&as_sdt=1%2C34&as_vis=1&as_ylo
                =1995&as_yhi=&num=5" +
                " See all articles</a></p>");
        } else {
            results_window.document.write
            ("<p><a href =
                http://scholar.google.com/scholar?" +
                "hl=en&as_sdt=1,34&as_vis=1&q=author:%22" +
                "%22&scisbd=1> See all
                articles</a></p>");
        }
        results_window.document.write(gs_result);
        results_window.focus();

        //if window is not focused close it
        results_window.onblur = function() {
            this.close();
        }
    });
}

//search in PubMed
else {
    var results_window = window.open

function (result) {
    $.each(result.esearchresult, function(i, item) {
        if (i == "querykey")
            query_key = item;
        if (i == "webenv")
            web_env = item;
        if (i == "idlist") {
            for (var j = 0; j < item.length; j++) {
                ids[j] = item[j];
            }
        }
    });
}

//ESummary is used to return document summaries (DocSums)
//for a list of input UIDs
url_summary =
'db=pubmed&query_key='
+ query_key + '&WebEnv='
+ web_env+'&retmode=json&retmax=5';

$.get(url_summary, function(data) {
  if (data.error == "Empty result - nothing todo")
    results_window.document.write ('Pubmed do not have articles by this author');
  else {
    var html = '';
    $.each(data.result, function(i, item) {
      for (var j = 0; j <= 4; j++) {
        if (i == ids[j]) {
          var author_list = '';
          var author_number = item.authors.length;

          //make a list of authors
          if (author_number == 1) {
            author_list = item.authors[0].name;
          } else if (author_number == 2) {
            author_list = item.authors[0].name + ', ' + item.authors[1].name;
          } else if (author_number == 3) {
            author_list = item.authors[0].name + ', ' + item.authors[1].name + ', ' + item.authors[2].name;
          } else {
            for (var i = 0; i < 3; i++) {
              if (i != 0) {
                author_list += ', ';
              }
              author_list += item.authors[i].name;
            }
            author_list += ',... ' + item.lastauthor;
          }

          //if title is empty use book title instead
          var title = "";
          if (item.title != "") {
            title = item.title
          } else {
            title = item.booktitle;
          }

          //create a link for each article
<table class="personlist">
  <tbody>
    <tr>
      <td id="Dr.A" class="tooltip"><img src="http://chip.unc.edu/files/2014/02/DrA.jpg" alt="" /></td>
      <td id="Dr.A" class="tooltip"><strong>Dr.A</strong>, PhD</p>
      <p>Professor at the <a href="http://www.cs.unc.edu/cms" target="_blank">Department of Computer Science</a> and</p>
      <p>Director of the <a href="http://www.renci.org/" target="_blank">Renaissance Computing Institute (RENCI)</a></p>
    </tr>
  </tbody>
</table>

google_scholars_results.php

<?php
  include '../CHIPv3/pop_up_window.css';
  include('simple_html_dom.php');

  //get search term from CHIP_faculty.html file
  $search_term = (isset($_GET['search_term']) ? $_GET['search_term'] : null);

  //create DOM from URL (this function is described in simple_html_dom.php)
  $html = "http://scholar.google.com/scholar?hl=en&as_sdt=1,34&as_vis=1&q=author:%22" . $search_term . "%22&scisbd=1&num=5";
// Dr. G published most articles in the end of 90s
// so her search link is different from other faculty
if (strcmp($search_term, "Dr.G+GG") == 0) {
            $search_term .
            "%22&hl=en&as_sdt=1%2C34&as_vis=1&as_ylo=1995&as_yhi=&num=5";
}

$content = file_get_html($html);

// parse the content of the html source page
foreach($content->find('div.gs_ri') as $article) {
    foreach($article->find('h3') as $title) {
        foreach($title->find('a') as $a) {
            $a = html_entity_decode($a);
            $a = preg_replace("/\&\#[a-z0-9]+;/i", "", $a);
            $a = str_replace("< i>", "", $a);
            echo $a;
            echo "<br>";
        }
        foreach($article->find('div[class=gs_a]') as $author) {
            echo $author;
            echo "<br>";
        }
    }
}

pop_up_window.css

<style>
body {
    font-family: Verdana, Arial, Helvetica, sans-serif;
    color: #333333;
    font-size: 11px;
    background: #FFFFFF;
}
a {
    color: #2376A1;
    text-decoration:none;
    outline:none;
}
a:hover {
    text-decoration:none;
}
p {
    color: #333333;
    line-height: 1.5em;
    margin: 4px 0 10px;
}
.gs_rt {
    font-size: medium;
}
</style>
Appendix B. Moderator Guide

Thank you very much for participating in this usability study. My name is Evgeniia, and I will guide you through the session of the study.

Before we begin I will introduce the Carolina Health Informatics Program, the purpose and the main steps of the study. Please feel free to ask any questions at any moment.

1) Carolina Health Informatics Program (CHIP) is a new program at UNC-CH that conducts research and training in health informatics sciences. More information about this program may be found at [http://chip.unc.edu](http://chip.unc.edu) website.

2) One of the webpages of CHIP website provides information about the CHIP faculty and researchers. This webpage was enhanced by adding dynamically updatable information about each member’s current publications.

3) Main purpose of this study is to assess the usability of this website/webpage and provide suggestions for further improvement.

4) The study will take about 30 minutes.

5) During the study you will be asked to perform six tasks so we can see whether the website works as intended. The tasks should be completed in order.

6) During the study I will record your on-screen activity and voice. No one except my academic advisor and me will see or hear the recordings. All recordings will be deleted when the data analysis is completed.

7) I encourage you to think aloud while working on the tasks.

8) Also, please complete 3 questionnaires: the Entry Questionnaire (5 questions),
the Exit Questionnaire (12 questions), and the Computer System Usability Questionnaire (QUIS - 19 questions).

9) The main goal of this study is to test the website, not you. There is no right or wrong answer so you don’t need to worry about making mistakes.

10) You can take a break at any point of the study.

Do you have any questions before we begin?
Appendix C. Usability Study Tasks

Task 1. Go to the “Faculty, scholars, and researchers prototype webpage”
http://ruby.ils.unc.edu/~kazymova/CHIPv3/chip_faculty.html. Take some time to study this page:

• scroll up and down,
• see how many people are presented on this page,
• in what order they are listed,
• what kind of information you have for each faculty

Suppose you are interested in the most recent articles by Dr. B. Use this webpage to find this information. Don’t use any search fields on the webpage or browser.

Task 2. Suppose you think that the most recent article by Dr. B looks very interesting to read. You want to read an abstract of this article. Find the abstract of his most recent article by using the links in the pop-up window.

Task 3. Suppose you decided to collaborate with Dr. B and want to see all his articles from PubMed. Find all articles by Dr. B from PubMed by using the link in the popup window.

Task 4. Suppose you are interested in research on data visualization. Find a potential faculty collaborator from this webpage who might be a good advisor/collaborator for your research.

Task 5. Suppose you are using PROMIS pediatric scale in your research. Find a faculty member who has expertise in applying this scale in research.

Task 6. Find at least one person for whom no recent articles are retrieved from PubMed or Google Scholar. How did you identify that person?
Appendix D. Entry Questionnaire

1. What is your occupation?
   • SILS student
   • CHIP faculty
   • UNC employee
   • UNC undergraduate student
   • UNC graduate student
   • Other:

2. Have you ever visited the Carolina Health Informatics Program website http://chip.unc.edu/ before?
   • Yes
   • No

3. Have you ever used PubMed?
   • Yes
   • No

4. Have you ever used Google Scholar?
   • Yes
   • No

5. What browser do you use?
   • Chrome
   • Internet Explorer
   • Mozilla Firefox
   • Safari
   • Opera
   • Other: ___________________
Appendix E. Exit Questionnaire

1. How do you assess the size of the text in the pop-up window?
   • Too small
   • Too large
   • Normal
   • Other: ____________________

2. How do you assess the size of the pop-up window?
   • Too small
   • Too big
   • Normal
   • Other: ____________________

3. How do you assess the initial location (upper-left corner) of the pop-up window on the screen?
   • The current location works well
   • Upper-right corner would work better
   • The pop-up window obscures the content of the webpage which is inconvenient
   • Other: ____________________

4. Pop-up window is used to show the most recent articles by each faculty. Is this a good solution? If no, what solution would work better?
   • Pop-up window works well
   • New tab would work better
   • New browser window would work better
   • Other: ____________________

5. Was the amount of information in the pop-up window (article title, authors list, journal, date) sufficient to complete the tasks?
   • Yes, it was sufficient
   • No, more information is needed
   • Other: ____________________

6. Was the number of articles (up to 5 most recent articles) in the pop-up window sufficient to complete the tasks?
   • Yes, up to 5 articles were enough to complete the tasks
   • No, I need more articles
   • Other: ____________________
7. Did you notice any articles shown in the pop-up window that don’t belong to a faculty who was clicked? If yes, provide the name of faculty.

8. In your opinion, what kind of articles does best characterize the faculty member interests?
   - The most recent ones
   - The most cited ones
   - Where the faculty is the first author
   - Where the faculty is the last author
   - Other: ______________________

9. Is there any noticeable lag when you do a click and the window pops up?

10. If you opened this webpage by yourself would you allow any pop-up windows in your browser? If no, why?

   - Yes
   - No
   - Other: ______________________

11. Did you have any technical difficulties while working on the tasks?

12. Please provide any suggestions for website improvement. ______________________
Appendix F. Computer System Usability Questions

1. Overall, I am satisfied with how easy it is to use this system
2. It was simple to use this system
3. I can effectively complete my work using this system
4. I am able to complete my work quickly using this system
5. I am able to efficiently complete my work using this system
6. I feel comfortable using this system
7. It was easy to learn to use this system
8. I believe I became productive quickly using this system
9. The system gives error messages that clearly tell me how to fix problems
10. Whenever I make a mistake using the system, I recover easily and quickly
11. The information (such as online help, on-screen messages, and other
documentation) provided with this system is clear
12. It is easy to find the information I needed
13. The information provided for the system is easy to understand
14. The information is effective in helping me complete the tasks and scenarios
15. The organization of information on the system screens is clear
16. The interface of this system is pleasant
17. I like using the interface of this system
18. This system has all the functions and capabilities I expect it to have
19. Overall, I am satisfied with this system