Heuristic-based user interface evaluation at Nanyang Technological University in Singapore

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ABSTRACT

This paper presents the results of a heuristic-based user interface evaluation of the Gateway to Electronic Media Services (GEMS) system at Nanyang Technological University (NTU) in Singapore. GEMS provides access to multimedia resources, bibliographic information, electronic document management, selective dissemination of information (SDI), booking of facilities, and several other services. Results of an evaluation of GEMS, based on Nielsen's 10-user interface heuristics involving 88 students are described. Details of a separate task-based study, involving 52 other participants, of the university's OPAC interface are also given as a means to compare GEMS with the OPAC in terms of usability, task performance and other factors.

Keywords: User interface evaluation, Heuristic Evaluation, GEMS, OPAC, Nanyang Technological University, Digital library

1. INTRODUCTION

The user interface (UI) of a public access system is a critical feature which impacts on the performance of that system. Evaluating user interfaces through usability tests have become one of the most important inputs to ongoing Web application development. The highly interactive nature of new applications imposes high demands on the users’ ability to navigate and access relevant information. Though designers have achieved these through the use of style guides and de facto standards, there is however no guarantee that the user interface will attain a high quality by these means only. Systematic user acceptance testing with actual users will remain important for the development of user-friendly Web-based systems. This work has greatly benefited from specific advances in usability engineering studies (Whiteside, Bennet and Holzblatt, 1988; Nielsen and Mack, 1994) and the more general work on designing usable artefacts (Norman, 1986, Landauer, 1995). The user interface of a Web-based information delivery system is a complex environment in which the system features must complement a variety of users’ personal characteristics, cognitive abilities, and task requirements. The framework for the development of a UI evaluation can be
developed by adopting various procedures including the Open Process Framework (Firesmith, 2001), the User Action Framework (2000) or the heuristic evaluation method (Nielsen, 1994). The latter makes an evaluation based on:

- user satisfaction;
- ease of learning:
- ease of use:
- error prevention;
- efficiency of the interface.

The heuristic evaluation method has been applied to several usability testing of library Websites particularly in American universities (Prown, 1999; Hennig, 2002).

The Nanyang Technological University (NTU) Library in Singapore uses an enterprise-wide information delivery system known as GEMS (Gateway to Electronic Media Services) to provide access for its users to a wide range of information resources and other services via a single graphical user interface (GUI).

These include multimedia courseware, online databases, audio and video resources, OPAC (Online Public Access Catalogue), and services such as electronic document management, selective dissemination of information (SDI) and the booking of NTU facilities. This study aimed to evaluate systematically the highly used UI for GEMS services using Nielsen's 10 heuristic principles (Nielsen, 1992). A secondary
evaluation between GEMS and the NTU’s OPAC system through a series of user-defined information seeking tasks was also undertaken.

Figure 2. NTU’s OPAC interface

The main objectives of the evaluation were fourfold:

- to discover users’ attitudes and perceptions about the GEMS system;
- to identify common problems faced by users while using the GEMS system;
- to assess the strengths and weaknesses of the GEMS system;
- to provide a set of recommendations for improvement.

The secondary evaluation complemented the main evaluation and aimed to assess the usability of the GEMS system in comparison to the traditional OPAC system at NTU. It focussed on the design and usability of the GEMS system and did not attempt to evaluate the services it offers, except in the case of cross-media searches where the GEMS performance was compared with the OPAC in carrying out a series of information tasks. Hence the study was strictly confined to UI issues in contrast to other system design issues. This work was based on a Master of Science in Information Studies programme dissertation that was earlier carried out at NTU (Lew, 2002).
2. BACKGROUND

The NTU Library, inaugurated in August 1981, currently comprises of the main Lee Wee Nam Library, Library 2 and Media Resource library. It has a collection size of 430,000 volumes mainly covering accounting, business, economics, management, mass communication, science and engineering. The open access collections are categorised according to the Library of Congress classification scheme. The library caters to an academic community of 26,000 who are mainly staff and students of the NTU. It also extends its resources and services to affiliated scholarly and research communities in Singapore.

In 1988, an online integrated catalogue system was introduced as part of the university’s automation initiative. Library users on separate NTU campuses could access the OPAC system through the NTU intranet to check bibliographic data and information on loan status. The search facilities of the OPAC are shown in Figure 2. The NTU OPAC also has a ‘one-search’ facility in which the users can search the catalogues of the National Institute of Education (NIE), National University of Singapore (NUS) and Singapore Polytechnic libraries’ bibliographic information databases. NTU’s library automation system is not one of the available commercial library automation systems in the market but was developed exclusively for NTU by a local IT company. Subsequently, NTU Library introduced the GEMS system in 1999 in order to provide access to its online databases, e-journals and past examination papers through its campus intranet. GEMS services also include:

- provision of a one-stop access to all types of media resources such as multimedia, courseware, database searching, audio and video resources, video-on-demand, OPAC and Internet browsing;
- electronic submission and management of e-documents to support NTU staff and students’ submission of Final Year Projects, Applied Research Projects, conference articles, theses, department news, calendars, prospectus, etc., to the NTU Library for processing and posting;
- SDI through a customisation feature that enable users to specify their search profiles and receive timely information on their desktops;
- booking of NTU resources facilities, which includes the booking of the campus lecture theatres, tutorial rooms, computer workstations, reading rooms and other facilities on campus.

Figures 3 and 4 show the GEMS personal account interface and cross-media search results interface of GEMS. This system was used for searching bibliographical details of all types of NTU library collections including books, journals, reports, standards, databases and e-documents and viewing audio-video tapes, CD-ROMs and booking teaching facilities. When GEMS was first launched, users could only access it through PCs in the library. By mid-2003 iGEMS (the second version of GEMS) was introduced and that could be accessed from anywhere on the campus intranet and via the Internet through a secured login interface. The findings from this comparative study of the GEMS system with its older NTU OPAC is expected to provide useful insights from users that could be used to refine and enhance the existing GEMS system.
Figure 3: GEMS Personal Account Interface

Figure 4: GEMS Cross media search results interface
3. RELATED RESEARCH WORK

The interface of an OPAC can be evaluated along three main perspectives, namely, the system's functionality, the effect of the interface on the users, and identification of specific problems with the system. While evaluating an UI, the use of guidelines, rules, standards and metrics are important instruments of analysis. Many previous evaluation studies showed that the guidelines of UIs were frequently violated by OPAC systems (Cherry et. al., 1998). Online training did not help users to use OPACs effectively (Slack, 1989; Huston, 1989; Pasanen, 1994; Cherry et. al., 1994). Findings revealed that most efforts have been focused on screen displays. Subject search aids were the weakest link in the development of OPAC systems (Cherry et. al., 1994). Attractive icons were found to be a popular means for both experienced and novice users to navigate the OPACs (Sulaiman & Meadows, 1995) particularly for multilingual access. Design of icons therefore had to be carefully constructed to convey meaningful directions.

Checklists became a popular form of evaluation in comparison with other methods of OPAC evaluation as highlighted by Oppermann and Reiterer(1997). Ravden and Johnson (1989) developed a checklist for evaluating the usability of human-computer interfaces consisting of nine variables, namely visual clarity, consistency, compatibility, informative feedback, explicitness, appropriate functionality, flexibility and control, error prevention and correction, and user guidance and support.

4. METHODOLOGY

Heuristic evaluation is an evaluation technique based on a set of ten principles (which are outlined later in this section) that were developed by Nielsen and Molich in 1990. In a study, Nielsen (1992) found that individual evaluators fared quite badly in doing heuristic evaluations, noting that each evaluator was only able to find between 20 to 51% of the usability problems in the interfaces they evaluated. On the other hand, evaluation by several evaluators, even if there were only three to five of them, could discover almost 75% of the usability problems. Nielsen (1992) also found that usability specialists were better than non-specialists for conducting heuristic evaluation. Major usability problems are more likely to be surfaced than minor problems in a heuristic evaluation, but more minor problems are found in absolute numbers. Heuristic evaluation applied to paper prototype implementation was not particularly effective as it was more difficult to surface missing interface elements.

Heuristic evaluation was however more effective in real and deployed systems evaluation (Nielsen, 1992). In another separate study by Nielsen and Landauer (1993), they found that the detection of usability problems as a function of number of users tested or heuristic evaluators employed can fit into a Poisson distribution. The model can also be used to plan the number of evaluations required to achieve the desired levels of thoroughness or benefits (maximum benefit/cost ratio for the number of evaluation needed). Desurvire, et al. (1993) found that heuristic evaluation and cognitive walkthroughs not only predicted problems observed in laboratory studies but also encouraged evaluators to suggest improvements. With these in mind, it can be seen that heuristic evaluation is an important and effective technique to identify GEMS’s interface problems or errors.
The reason for selecting the heuristic evaluation is that it can be implemented quickly and conveniently through a competent pool of evaluators. For this study, a questionnaire (as shown in Annex A) was designed based on Nielsen's ten heuristics and conducted across a sampling of postgraduate and undergraduate students of NTU.

The first section of the questionnaire dealt with users’ profiles such as their background and preferences. The second section contained questions pertaining to the ten heuristic principles (Nielsen, 1994):

- visibility of system status;
- match between system and the real world;
- user control and freedom;
- consistency and standards;
- error prevention;
- recognition rather than recall;
- flexibility and efficiency of use;
- aesthetic and minimalist design;
- help users recognise, diagnose and recover from errors;
- help and documentation.

Users were also asked to comment on their overall impression of the GEMS system such as the most and the least liked features, problems encountered and some advanced useful features that could be incorporated into the future versions of GEMS.

Before commencing the actual evaluation, a pilot study was conducted with a group of 10 graduate students who were pursuing the MSc Information Studies (IS) programme at NTU. The pilot study aimed to discover inadequacies in questionnaire design such as ambiguity and inconsistency in questions. The revised questionnaire was administered in October 2001 to 100 student users in the NTU Library. Students form an important pool of regular users of NTU’s OPAC and GEMS systems, utilising these systems for their studies, project work and research work. To maintain consistency in the number of different types of users, 25 users was chosen for each category including postgraduate (PG) males, PG females, undergraduate (UG) males and UG females. A total of 88 users (88%) responded and these were used in the analysis of the heuristic evaluation. The respondents were sampled based on their individual profiles as PG males and females, and as UG males and females. Of the total surveyed, there were 20 PG males, 25 PG females, 21 UG male and 22 UG females.

In the secondary evaluation exercise which compared the OPAC with GEMS, a separate task-based study comprising four information seeking tasks were designed and administered to a group of 52 participants (from the original 100 who participated in the first evaluation study) selected randomly at the NTU Library. This evaluation was carried out in the Information Studies laboratory of NTU. The study was conducted during a period of six months from September 2000 to February 2001 which includes library’s peak time use (September and October) due to second semester exams, inter-semester break time (November and December) and next semester starting time (January and February). So, this study covered all the timings of a semester including the vacation period. The four tasks included:
Participants were asked to identify answers from both systems. During this study, the researchers observed the students’ performance while using both the systems and recorded the time taken to complete the task. In addition, the study also gathered participants’ perception towards the system’s learnability, ease of use, ease of remembering, error rates per session, nature of errors, system’s aesthetics, navigability, and use of technical jargon.

The 52 participants were made up of 16 PG males, 17 PG females, 9 UG males and 10 UG females. The participants in this study were a subset of the main group who participated in the heuristic evaluation. The total time taken for each task included the time for reading the task description, conducting the search, finding and recording the answers. It was noticed that the participants felt somewhat uncomfortable while the researcher was monitoring their task exercise. However, the impact of the researcher’s observation on participants was not covered in this study. Throughout the evaluation, no help was provided to the participants even when problems were encountered. Participants were asked to record their problems in a form provided to them. In order to minimise the ‘learning effect’, half of the participants started with the GEMS questionnaire first followed by OPAC to accomplish their tasks, while the other half of the participants did the reverse.

This study was limited to university students only and faculty and staff members of the NTU were not included in this study. Ideally, the study should incorporate all these three user groups. A larger sample size than the one used in the study would also provide a better representation of the user population. Due to time and manpower limitations, this study focussed on the usability aspects of the interface and did not cover other design areas of the system. Finally the sample size of the second study (52) was almost half of the first study (88). Due to time limitations and other constraints, a number of participants from the first study did not participate in the second study. As a result of these limitations, the findings presented subsequently are indicative but not generalisable to the population of OPAC and GEMS users of NTU Library.

5. FINDINGS ON HEURISTICS EVALUATION of GEMS

5.1 Results from the questionnaire

The results of the comments made on the 10 heuristic principles are now given.

(a) Visibility of system status: Table 1 shows that more than half (63.6%) of the users felt that GEMS does provide feedback on system availability some, most or all of the time. However, the remainder, more than a third (36.4%) reckoned that such feedback was not obvious.
Table 1. Provision for feedback (N=88)

<table>
<thead>
<tr>
<th>% users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
</tr>
<tr>
<td>Hardly ever</td>
</tr>
<tr>
<td>Some of the time</td>
</tr>
<tr>
<td>Most of the time</td>
</tr>
<tr>
<td>All the time</td>
</tr>
</tbody>
</table>

Table 2 shows that 77.2% of the users felt that the feedback generated by the system was accurate or appropriate.

Table 2. Appropriateness of feedback (N=88)

<table>
<thead>
<tr>
<th>% users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely inappropriate</td>
</tr>
<tr>
<td>Inappropriate</td>
</tr>
<tr>
<td>Acceptable</td>
</tr>
<tr>
<td>Appropriate</td>
</tr>
<tr>
<td>Very appropriate</td>
</tr>
</tbody>
</table>

On system speed, 76% of the users felt that the system response time was fast or reasonable, though 24% of the users found that the feedback was a bit slow. This may be due to several reasons including the slow response of the user’s PC, network lines, server and peak timings. This indicates that GEMS feedback did not exhibit serious drawbacks in terms of speed and appropriateness. However, half the users felt that there was no feedback from the GEMS system while they were navigating through the websites.

(b) Match between system and the real world: Most (93.2%) of the users found that the language used in the GEMS system was natural with a reasonable amount of technical jargon. Although a small percentage (6.8%) of users found that the language used was too technical.

(c) User control and freedom: Table 3 shows the users’ perception about navigation controls of the GEMS system. It is evident that more than half (60%) of the users believed that there were no user control features undo, redo previous actions. Also, 20% of the users did not find the system self-intuitive and hence have concluded that it was difficult to learn, use and remember. Quite surprisingly however, almost half (51.7%) of them acknowledged the existence of the Emergency Exit button.

Table 3. GEMS Navigation Tools (N=88)

<table>
<thead>
<tr>
<th>Features</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Undo’ and </code>redo’ feature</td>
<td>39.2%</td>
<td>60.8%</td>
</tr>
<tr>
<td>Provision of shortcuts required</td>
<td>44.5%</td>
<td>55.5%</td>
</tr>
<tr>
<td>Navigation buttons provided on each page</td>
<td>67.0%</td>
<td>33.0%</td>
</tr>
<tr>
<td>´Emergency Exit’ to leave the system</td>
<td>51.7%</td>
<td>48.3%</td>
</tr>
</tbody>
</table>
(d) **Consistency and standards**: Table 4 shows how users perceive the screen layout of the GEMS interface. Almost all users were comfortable with the graphics, and layout design in the GEMS system.

Table 4. **Consistency and standards in the GEMS interface (N=88)**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to understand the conventions used</td>
<td>0.0%</td>
<td>9.1%</td>
<td>46.6%</td>
<td>40.9%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Consistency of screen layouts used</td>
<td>1.1%</td>
<td>3.4%</td>
<td>38.6%</td>
<td>46.7%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Consistency of words used</td>
<td>1.1%</td>
<td>1.1%</td>
<td>36.4%</td>
<td>52.3%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Consistency of graphics and icons used</td>
<td>2.3%</td>
<td>4.6%</td>
<td>33.0%</td>
<td>48.7%</td>
<td>11.4%</td>
</tr>
<tr>
<td>Consistency of colours used</td>
<td>1.1%</td>
<td>5.7%</td>
<td>31.8%</td>
<td>50.0%</td>
<td>10.2%</td>
</tr>
</tbody>
</table>

(e) **Error prevention**: Respondents were divided over error messages (48.9% registered a negative response) and opinion was not conclusive about the ease with which errors could be corrected. Only 21.6% of the users encountered problems while entering information into the GEMS system. The major problems encountered by the users included:

- wrong ID or password;
- not knowing how to change expired passwords;
- difficulty with cross-media searching;
- system hangs quite often;
- inability of GEMS to support other languages (e.g. German);
- unable to find books using ISBN number;
- cannot access school’s e-mail;
- inconvenient to retype/change the keywords while conducting keyword search again.

(f) **Recognition rather than recall**: It can be seen from Table 5 that 20.5% of the users felt that the instructions for using GEMS (help file) were not readily available and visible. However, the majority of the users found it easy to recognise instructions (79.5%), use the graphical menus (91%) and rated positively the usefulness of the logical and indicative text buttons (90.8%) that were being used in the GEMS user interface.

(g) **Flexibility and efficiency of use**: 80% of GEMS users noticed the absence of ‘accelerators’ or advanced user features for experienced users. As such, both experienced and novice users would be required to perform a step-by-step search. In addition, 81% of the users also indicated that frequent, repeated actions cannot be customised in the GEMS interface. These percentages imply that the GEMS system is not configured to be tailored to different user competencies in terms of task completion.
Table 5. Affordance and visibility of GEMS system (N=88)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructions for using GEMS are visible.</td>
<td>4.6%</td>
<td>15.9%</td>
<td>44.2%</td>
<td>30.7%</td>
<td>4.6%</td>
</tr>
<tr>
<td>The graphical menus are easy to recognise.</td>
<td>0.0%</td>
<td>8.0%</td>
<td>40.9%</td>
<td>43.1%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Text buttons are ‘logical and indicative’</td>
<td>2.3%</td>
<td>6.9%</td>
<td>37.5%</td>
<td>43.1%</td>
<td>10.2%</td>
</tr>
</tbody>
</table>

(h) Aesthetic and minimalist design: Table 6 shows the users views about the GEMS system design with 80.6% of the users feeling that a typical Web page of GEMS was sufficiently clear and minimal in design sophistication. They also felt that there was no ‘cluttering effect’ of screen elements or overloading of information on the screen. 91.2% of the users perceived the GEMS Web pages as containing adequate information to perform a task and 87.5% felt that relevant information only was provided. However, 20% of the surveyed users begged to differ on information clutter and about 12.5% commented on the irrelevance and inadequacy of content. However, only 9% of the respondents noted that the intervening dialog boxes provided inadequate information for the user and hence could be eliminated if they were not absolutely necessary.

Table 6. Aesthetical design of the GEM webpages (N=88)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design of a page contains minimum screen elements.</td>
<td>4.6%</td>
<td>14.8%</td>
<td>51.0%</td>
<td>21.6%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Design of a page provides relevant information only.</td>
<td>1.1%</td>
<td>11.4%</td>
<td>47.6%</td>
<td>31.9%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Dialog boxes provide adequate information to perform the task.</td>
<td>2.2%</td>
<td>6.8%</td>
<td>37.6%</td>
<td>45.4%</td>
<td>8.2%</td>
</tr>
</tbody>
</table>

(i) Help users recognise, diagnose and recover from errors: A total of 69.3 % of the users felt that the error messages issued by the GEMS were comprehensible and written in plain language. In addition, 44.3% of the users also found that the error messages were precise in the identification of the problem. Finally, 33% of the respondents highlighted that the error messages recommended a solution. Though the majority of the respondents found the help messages comprehensible, the overall ‘help’ provided by the GEMS system was generally inadequate for user tasks. There was thought to be a disconnection between the error messages and the assistance provided by the help files as the instructions were not directly related to the problems encountered.
(j) **Help and documentation:** Generally, respondents felt that there was a need for online help in the GEMS system. Table 7 indicates that more than half of the respondents found the help provided by the GEMS system as inadequate. In fact, a large percentage (88.6%) of the respondents felt a strong need for multimedia or graphics based online help rather than simple textual instructions.

<table>
<thead>
<tr>
<th>Level of Help Needed</th>
<th>% of Users agreed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step-by-step help is provided</td>
<td>37.5 %</td>
</tr>
<tr>
<td>Help given is simple</td>
<td>58.0 %</td>
</tr>
<tr>
<td>Comprehensive help is given</td>
<td>15.9 %</td>
</tr>
<tr>
<td>Useful to have online help and documentation</td>
<td>88.6 %</td>
</tr>
</tbody>
</table>

**Online documentation should be in:**

- (a) Multimedia  50.0 %
- (b) Text with graphics  54.6 %
- (c) Text only  9.1 %

5.2. **Overall impressions of users**

Table 8 highlights the general response towards the overall impression of GEMS. Common remarks included: system’s instability led to navigational difficulties and the inability of the search mechanism led to support query statement formulation. Survey responses to this section were not sufficient to make definitive conclusions.

<table>
<thead>
<tr>
<th>System Impression</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>System is quite easy to use</td>
<td>15.9%</td>
</tr>
<tr>
<td>System is highly integrative, easy and quick to access</td>
<td>12.5%</td>
</tr>
<tr>
<td>System in general is ‘alright’</td>
<td>9.1%</td>
</tr>
<tr>
<td>System is unfriendly and not easy to use</td>
<td>8.0%</td>
</tr>
<tr>
<td>System is ‘pretty good’ and convenient</td>
<td>5.7%</td>
</tr>
<tr>
<td>System is slow in loading</td>
<td>3.4%</td>
</tr>
<tr>
<td>System is easy to learn and the information provided is helpful</td>
<td>2.3%</td>
</tr>
<tr>
<td>System is a one-stop information centre</td>
<td>2.3%</td>
</tr>
</tbody>
</table>

When asked about the best-liked features of the system, the five highest ratings from users included:

- nice, simple and colourful graphics and layouts with presence of multimedia (14.8%); support for cross-media search (10.2%);
- personalised settings to use (9.1%);
- simple and natural dialogues with ease of use (4.5%);
- informative (2.3%).

When asked about the least-liked features of the system, the five highest ranked include those of:
- slow system (8.0%);
- no online help or inadequate help (6.8%);
- navigibility (4.5%);
- cannot access through Internet (4.5%);
- system hangs quite often (3.4%).

Other preferred features currently unavailable in GEMS included the ranking of results, advanced search features, logical display of search results, and shortcuts for advanced users. Users also commented on the need for backward or undo buttons, detailed online help documentation, additional animation or multimedia features, frequent system and content updates, problem resolution steps for error messages, password reminders, personable user interface and system accessibility via the Internet.

6. USABILITY STUDY

The secondary study which involved a comparative usability study between GEMS and the OPAC system showed that users preferred the new GEMS system owing to its appealing layout. However, learnability and retention was an issue for most of the surveyed users. Navigational difficulties were also inherent and the sense of ‘getting lost’ in a matrix of searches compared to the linear search pathway of the OPAC system. This accounts for the larger number of ‘errors’ committed by GEMS users.

From Table 9 it can be seen that 67.3% of the users found the OPAC system to be easy or very easy to use with a negligible 3.8% indicating difficulty of use. Comparatively, 25% of the respondents highlighted difficulties of use with GEMS. Since GEMS is a campus-wide intranet-based system designed to facilitate easy access and retrieval of information, foster greater efficiency in booking and processing requests, the findings indicate the need for an enhancement of usability features.

<table>
<thead>
<tr>
<th></th>
<th>Ease of Use</th>
<th>Learnability</th>
<th>Easy to Remember</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OPAC</td>
<td>GEMS</td>
<td>OPAC</td>
</tr>
<tr>
<td>Very Easy</td>
<td>19.2%</td>
<td>9.6%</td>
<td>17.3%</td>
</tr>
<tr>
<td>Easy</td>
<td>48.1%</td>
<td>32.7%</td>
<td>48.1%</td>
</tr>
<tr>
<td>Average</td>
<td>28.9%</td>
<td>32.7%</td>
<td>32.7%</td>
</tr>
<tr>
<td>Difficult</td>
<td>3.8%</td>
<td>15.4%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Very Difficult</td>
<td>0%</td>
<td>9.6%</td>
<td>0%</td>
</tr>
</tbody>
</table>

In terms of learnability, 65.4% (as against 1.9%) of the surveyed users found that the OPAC was easier to learn compared to the GEMS system. In terms of easy to remember, a marginal 3.8% indicated ‘very difficult’ for GEMS. A large number of users found OPAC (50%) easy to remember, while GEMS had a fairly divided and distributed response.
Table 10. Number of Errors per session - OPAC vs. GEMS (N=52)

<table>
<thead>
<tr>
<th>No. of Errors per session</th>
<th>OPAC</th>
<th>GEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage</td>
<td>Percentage</td>
</tr>
<tr>
<td>None</td>
<td>21.2</td>
<td>21.2</td>
</tr>
<tr>
<td>One</td>
<td>40.4</td>
<td>38.5</td>
</tr>
<tr>
<td>Two</td>
<td>30.8</td>
<td>17.3</td>
</tr>
<tr>
<td>Three</td>
<td>5.8</td>
<td>13.5</td>
</tr>
<tr>
<td>Four or more</td>
<td>1.9</td>
<td>9.6</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The number of errors made by users in completing the assigned information tasks were also noted and shown in Table 10. Errors made by the users included the selection of wrong options, fields and search mechanism in an interface while performing the four tasks assigned to them. About 21.2% of users reported that they did not make any errors while using both the systems.

A large majority of OPAC users (71.2%) highlighted that the number of errors made in a single session was one or two. About 55.8% of GEMS users made one or two errors and about 23% made three or more errors. This demonstrated that the GEMS users were prone to committing more errors. As evident in Table 11, 44% of the users found that the GEMS interface was more appealing than the traditional OPAC interface (27%). Indeed, the GEMS system is highly graphical, having good contrast and pleasant colours that are applied consistently across all the Web pages.

Table 11. Pleasant layout - OPAC vs. GEMS (N=52)

<table>
<thead>
<tr>
<th>OPAC</th>
<th>GEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>Percentage</td>
</tr>
<tr>
<td>Very Pleasant</td>
<td>3.9</td>
</tr>
<tr>
<td>Pleasant</td>
<td>23.1</td>
</tr>
<tr>
<td>Acceptable</td>
<td>53.9</td>
</tr>
<tr>
<td>Confusing</td>
<td>17.3</td>
</tr>
<tr>
<td>Very Confusing</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Table 12 compares the two systems in terms of navigability, ease in which users ‘got lost’ and the use of jargon. A good 60% of the users found it easy to navigate in the OPAC compared to a moderate 40% for GEMS system. In fact, 12% of the users found GEMS to be difficult to navigate. This is probably due to the lack of basic navigational buttons such as ‘previous’, ‘next’, ‘return’, and ‘home.’
Ease of navigability shares an inverse relationship with that of ease of getting lost, particularly for the ‘easy’ users category. Whilst 44.2% registered high navigability in the OPAC system, 3.9% registered that they found it easy to get lost. Similarly for GEMS, 28.9% considered ease of navigability (about half of the number that considered the same for OPAC) and 9.6% for the ease of getting lost (twice the number who considered the same for OPAC).

More than half the respondents found that the language used in both systems was simple. A small percentage of users highlighted the difficulties in understanding the jargon in the OPAC (4%) and GEMS (9%). However, there were no significant differences between OPAC and GEMS systems in terms of the percentage of respondents who found them easy to understand. The usage of technical jargon is basically very minimal in both the systems, and hence users responded that they faced little problems in this respect.

All the 52 users completed the four given tasks within the time in a session. The time taken to perform each task is tabulated in Table 13, averaged and grouped as shown in Table 14.

### Table 12. OPAC vs GEMS in terms of Navigability, Easy To Get Lost and Jargon (N=52)

<table>
<thead>
<tr>
<th></th>
<th>Navigability</th>
<th>Easy to get lost</th>
<th>Jargon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OPAC</td>
<td>GEMS</td>
<td>OPAC</td>
</tr>
<tr>
<td>Very Easy</td>
<td>15.4%</td>
<td>11.5%</td>
<td>9.6%</td>
</tr>
<tr>
<td>Easy</td>
<td>44.2%</td>
<td>28.9%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Average</td>
<td>32.7%</td>
<td>48.0%</td>
<td>41.3%</td>
</tr>
<tr>
<td>Difficult</td>
<td>5.8%</td>
<td>5.8%</td>
<td>41.3%</td>
</tr>
<tr>
<td>Very Difficult</td>
<td>1.9%</td>
<td>5.8%</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

Ease of navigability shares an inverse relationship with that of ease of getting lost, particularly for the ‘easy’ users category. Whilst 44.2% registered high navigability in the OPAC system, 3.9% registered that they found it easy to get lost. Similarly for GEMS, 28.9% considered ease of navigability (about half of the number that considered the same for OPAC) and 9.6% for the ease of getting lost (twice the number who considered the same for OPAC).

More than half the respondents found that the language used in both systems was simple. A small percentage of users highlighted the difficulties in understanding the jargon in the OPAC (4%) and GEMS (9%). However, there were no significant differences between OPAC and GEMS systems in terms of the percentage of respondents who found them easy to understand. The usage of technical jargon is basically very minimal in both the systems, and hence users responded that they faced little problems in this respect.

All the 52 users completed the four given tasks within the time in a session. The time taken to perform each task is tabulated in Table 13, averaged and grouped as shown in Table 14.

### Table 13. Average Task Time - OPAC vs GEMS (N=52)

<table>
<thead>
<tr>
<th>Task</th>
<th>OPAC</th>
<th>GEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVG</td>
<td>AVG</td>
</tr>
<tr>
<td>1</td>
<td>71</td>
<td>85</td>
</tr>
<tr>
<td>2</td>
<td>98</td>
<td>68</td>
</tr>
<tr>
<td>3</td>
<td>64</td>
<td>57</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>303</td>
<td>464</td>
</tr>
</tbody>
</table>

(PG–M : Post-graduate male; PG–F: Post-graduate female)
(UG–M: Undergraduate male; UG–F: Undergraduate female)

Generally, the undergraduates took more time to complete the given task than the post-graduates. In using the OPAC system, undergraduates (both males and females) took 464 seconds to complete the four tasks in comparison to 303 seconds for the
postgraduates students. This can be attributed to the fact that most PG users were Masters degree students from the Information Studies programme who have undergone information literacy training (e.g. using Boolean operators, query formulation, refinement, re-formulation and other types of tasks) whereas the UG users were exposed to less rigorous search skills training at the NTU Library. A t-test conducted on the average time taken for tasks completion between GEMS and OPAC systems showed no significant difference between these two groups of users.

Table 14. Average Task time - GEMS vs OPAC (N=52)

<table>
<thead>
<tr>
<th>Tasks</th>
<th>OPAC (Average time/Sec)</th>
<th>GEMS (Average time/Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>69</td>
<td>61</td>
</tr>
<tr>
<td>Task 2</td>
<td>101</td>
<td>90</td>
</tr>
<tr>
<td>Task 3</td>
<td>106</td>
<td>122</td>
</tr>
<tr>
<td>Task 4</td>
<td>106</td>
<td>138</td>
</tr>
<tr>
<td>Average time for each task</td>
<td>95.5</td>
<td>103</td>
</tr>
</tbody>
</table>

It was also found that there were no significant differences in task completion times between the male and female users as shown in Table 15. For GEMS, it was noted that female users were a little slower in Tasks 1 and 4.

Table 15. Task time in OPAC and in GEMS - Male vs. Female users (N=52)

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Male Users (Average time/Sec)</th>
<th>Female Users (Average time/Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OPAC</td>
<td>GEMS</td>
</tr>
<tr>
<td>Task 1</td>
<td>78</td>
<td>73</td>
</tr>
<tr>
<td>Task 2</td>
<td>108</td>
<td>91</td>
</tr>
<tr>
<td>Task 3</td>
<td>106</td>
<td>134</td>
</tr>
<tr>
<td>Task 4</td>
<td>108</td>
<td>104</td>
</tr>
<tr>
<td>Average time for a task</td>
<td>100</td>
<td>101.5</td>
</tr>
</tbody>
</table>

Shashaani (1994) in a study of 902 boys and 828 girls in a secondary school found that there was a direct relationship between gender differences attributed to the use of computers and their subsequent attitudes towards using. The results showed that male computer experiences were stronger compared to females and correspondingly boys shared more positive attitudes towards computers than girls. Nicholson et. al., (1998), in another study, noticed that young children, particularly girls, have more negative experiences in learning computers in a mixed sex group environment. These early negative experiences may affect their interaction with computers in the future. Gefen and Straub(1997) highlighted that though women and men differ in their perceptions of email as a mode of communication, there was no difference in both sexes’ ability to use email. The results of this heuristic evaluation study reinstate earlier findings as there were no significant gender differences in users ability to use the GEMS or OPAC. The findings however need to be moderated given the fact that the presence of observers generated unease and these might have negatively impacted the results. Also there is considerable variation between these two systems in that the GEMS system
offered many alternative possibilities for searching (e.g. searching for books, journals, A-V tapes, CDs, etc) in comparison to the more traditional OPAC system.

7. SUMMARY OF KEY FINDINGS

GEMS’s key strengths lay in its attractive user interface and the ability to interact in natural language. The factors that contribute to its overall user acceptance are namely its adoption of consistency in terms of conventions used, screen layouts, minimum use of colours, and use of graphics and icons. The level and frequency of feedback provided by the system is inadequate though acceptable. The weaknesses of the GEMS system lie in its functionality including ease of use, learnability and ease of remembering. According to Jordan et al. (1991), in such circumstances, the system will definitely affect user's performance negatively. This surfaced in the comparative usability study where users using the GEMS system made more mistakes. It highlighted that an attractive and graphical user interface is sometimes not as functional as one that is simple and easy-to-use. It was also perceived that the GUI should have simplified icons and visible screen instructions to improve overall performance.

The time-to-tasks study between the post graduate and undergraduate users demonstrated the need for search tips, FAQs, and an online search guide to improve the current level of search performance. In general, the OPAC system yielded better results than the GEMS system for information search and retrieval. This is largely due to OPACs superior search engine capability and search features which includes field search (e.g. author, title, subject, keyword, etc.), qualifying searches, range searches and other complex Boolean searches. The GEMS search engine is somewhat limited as it is primarily a full-text search engine which performs keyword searching with little scope for advance searching.

8. CONCLUSIONS

The implementation of the GEMS system by NTU was a bold but necessary step to integrate and manage the provision of information services for all her patrons. Users prefer to use GEMS for its one-stop point for accessing various services. Its continued success and acceptance lies in the users’ perceptions and attitudes towards the system and in its ability to deliver these services through an interactive user interface. A number of key developmental areas have been identified as a result of the evaluation.

The following could be addressed in the future upgraded versions of GEMS:

- Addition of basic navigational buttons and functions (such as ‘Next’, ‘Previous’, ‘Return’ and ‘Undo’ buttons;
- Provisions to be made in the system to access GEMS directly through the Internet in addition to the current intranet;
- Provision of additional online help documentation along with enhanced search tips and examples’
- Ensuring that the content is kept relevant through regular content updates.
- Improving error handling messages through enhanced functionalities which provide suggestions and examples of problem resolutions;
• Cosmetic improvements to the existing user interface with added interactivity;
• Incorporating guest logins for partial access to the information and services available in GEMS. A “forget password” service that would generate an immediate reply and a password reminder to the patron’s email address.

In the final analysis, a more robust search engine would critically enhance GEMS service offerings. The engine should be able to undertake alternative search techniques which include the use of non-Boolean retrieval techniques; additional controlled and uncontrolled information access points; acceptance of search expressions in thesaurus supported natural language; dictionary support for abbreviations; synonyms or spelling variants; provision of context-dependent related searches; browsing records through standard terms/thesaurus to enhance searching, and providing a ranking of results in order of relevance.

References
Annex A

HEURISTICS EVALUATION OF THE GEMS SYSTEM - QUESTIONNAIRE

A. Background Information

Age: _____________ years  Gender: _____________
Occupation: ________________________
Educational Qualifications: ___________________________
No. of years of Computer Experience: ___________________
Length of experience with GEMS System: _____________

B. Users’ Survey on GEMS system based on heuristics principles

Visibility of system status

1. Does GEMS keep you informed about what is going on through feedback?

Never           Hardly Ever          Some of the         Most of the          All of the
Times               Times              Times

2. Is the feedback given appropriate?

Completely         Inappropriate       Acceptable         Appropriate            Very
Inappropriate                 Appropriate

3. Is the interface providing feedback in reasonable time?

Very Fast                Fast                Reasonable              Slow                Very Slow

Match between system and the real world

4. Is the language use in GEMS natural?

Highly Technical     Technical       Reasonable amount     Natural           Very natural
of technical jargon            Language used

User control and freedom

5. GEMS has the features ‘undo’ & ‘redo’

Yes No

6. Are shortcuts available when required

Yes No

7. Each page on GEMS provide all the navigation buttons

(previous, next, home).

Yes No

8. Each page on GEMS provides an ’Emergency Exit’ to leave the system.

Yes No

Consistency and standards

9. It is easy to understand the conventions used throughout GEMS.

Disagree 1 2 3 4 5 Agree

10. Same consistency of screen layouts is used throughout GEMS.

Disagree 1 2 3 4 5 Agree
11. Same consistency of **words** is used throughout GEMS.  
   Disagree 1 2 3 4 5 Agree

12. Same consistency of **graphics and icons** are used throughout GEMS.  
   Disagree 1 2 3 4 5 Agree

13. Same consistency of **colours** are used throughout GEMS.  
   Disagree 1 2 3 4 5 Agree

**Error Prevention & Correction**

14. Does the system promptly inform the user when it detects an error?  
   
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>Most of the times</td>
<td>Sometimes</td>
<td>Never</td>
<td></td>
</tr>
</tbody>
</table>

15. Is it easy for the user to correct errors?  
   
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Very Easy</td>
<td>Easy</td>
<td>Difficult</td>
<td>Very Difficult</td>
<td></td>
</tr>
</tbody>
</table>

16. Do you encounter any problems when entering information into the GEMS system. **Yes / No**  
   If Yes, please describe the problem:

---

**Recognition rather than recall**

17. Instructions for using GEMS are visible.  
   Disagree 1 2 3 4 5 Agree  
   (Not visible)  
   (Prominent)

18. The graphical menus provided on the screen are easy to recognize.  
   Disagree 1 2 3 4 5 Agree

19. Texts buttons are ‘logical and indicative’ (**i.e. users can understand the meaning of the text** buttons/menus).  
   Disagree 1 2 3 4 5 Agree

**Flexibility and efficiency of use**

20. GEMS provide ‘accelerators or shortcuts’ for experienced users.  
    **Yes / No**  
    (For example, pressing only one function key to perform a task)  
    If Yes, please describe the feature:

---

21. Frequent actions can be customized in the GEMS interface.  
    **Yes / No**  
    (For example, features or facilities can be personalized to appear on the interface)  
    If Yes, please describe the feature:

---

**Aesthetic and minimalist design**

22. Design of a page contains minimum screen elements.  
   Disagree 1 2 3 4 5 Agree

23. Design of a page provides relevant information only.  
   Disagree 1 2 3 4 5 Agree

24. Dialog boxes provide adequate information to perform the task.
Help the users in recognizing, diagnosing and recovering from errors

25. GEMS error message contains the following: Yes
   No
   a. Express in plain language
   b. Precisely indicate the problem
   c. Suggest a solution

Help provided by the GEMS system

26. Step-by-step help is provided.
27. Help given is simple.
28. GEMS provide comprehensive help to solve your problem.

Documentation

29. In your opinion, is it useful to have GEMS documentation online? Yes / No
   If Yes, which type of format do you like the documentation to be in?

   Multimedia  ( )
   Text with graphics  ( )
   Text Only  ( )
                   Others if any, please specify ________________

   Others

30. Please provide an overall impression of GEMS, how you feel about it, its ease of use etc.

   ____________________________________________________

31. What are the features you like best about GEMS?

   ____________________________________________________

32. What are the features you like least about GEMS?

   ____________________________________________________

33. List the problems you have encountered while using GEMS interface.

   ____________________________________________________

34. Please suggest some ideas about what you would like to see in GEMS.

   ____________________________________________________

~ Thank you for your help and participation ~