How Are Usability Elements - Efficiency, Effectiveness, and Satisfaction - Correlated with Each Other in the Context of Digital Libraries?

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ABSTRACT
This study examines the relationships amongst three major usability elements – efficiency, effectiveness, and satisfaction. Based on an experiment involving twelve subjects, this pilot study measured the efficiency, effectiveness, and subjective satisfaction of an academic digital library system. The preliminary results showed all three usability elements are highly correlated with each other. In particular, the correlation between effectiveness and satisfaction is much higher than the other pairs of correlations.

Keywords
Usability, Correlation, Digital Library, Efficiency, Effectiveness, Satisfaction

INTRODUCTION
While many studies have identified usability elements for assessment, few have explored the relationships amongst usability elements. This study intends to examine how usability elements are correlated with each other in the context of a digital library. In this study, we selected three major usability elements – efficiency, effectiveness, and satisfaction – based on the International Standards Organization’s (ISO) 9241-11 standard (ISO, 1998), one of most widely cited usability models in usability studies. According to ISO 9241-11, usability is defined as ‘the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use’ (ISO, 1998, p. 2). In this pilot study, the academic digital library refers to an augmentation of a traditional academic library, which includes electronic subscription, access to online database, and virtual references comprehensively (Joo & Lee, in press).

RESEARCH QUESTIONS
This study intends to answer the following research question: How are the three elements of usability – efficiency, effectiveness, and satisfaction, correlated with each other?

METHODODOLOGY
Sample
Twelve graduate students were invited to participate in the experimental tasks involving resource searching using the Yonsei University Digital Library (library.yonsei.ac.kr). To control for the factor of familiarity with a system, we selected subjects who had never used the Yonsei University Digital Library, so the subjects of this study were from other universities, not from Yonsei University. Majors of subjects ranged from English literature, Political Science, Education, Psychology, to Geography.

Conceptual Operationalization
In this study, the ISO 9241-11 standard was employed to operationalize the concepts of three usability elements. According to the ISO 9241-11 standard model, usability consists of three elements – effectiveness, efficiency, and satisfaction. The conceptual operationalization for each element is following:
• effectiveness: level of completeness at which users achieve specified goals;
• efficiency: resources used in completing a task; and
• satisfaction: positive attitudes toward using the system (ISO, 1998).

Measurement
By adopting Jeng’s (2006) usability assessment model, measurement scales were developed for each usability element:
• efficiency – time spent to complete the tasks;
• effectiveness – the proportion of successfully completed tasks;
• satisfaction – seven-point Likert scale from “not satisfied at all” to “very satisfied”

Search Task
In the experiment, subjects were asked to complete seven search tasks using the Yonsei University digital library. The seven search tasks are as follows:
(1) Finding a bibliography of a monograph
(2) Finding a domestic electronic journal article full-text
(3) Finding an overseas electronic journal article full-text
(4) Finding a domestic dissertation full-text

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(5) Finding an overseas dissertation full-text
(6) Finding a domestic electronic book full-text
(7) Finding an overseas electronic book full-text

RESULTS
Using the identified measures above, efficiency, effectiveness, and satisfaction were assessed in the Yonsei University digital library.
Table 1 shows the time spent by subjects in completion of experimental tasks, which represents the efficiency of the system. While the subjects completed Task 1 in a short time, they spent a relatively longer time on Task 2, 3, and 5.

Table 1. Time spent (seconds) in completion of tasks

<table>
<thead>
<tr>
<th></th>
<th>Task 1</th>
<th>Task 2</th>
<th>Task 3</th>
<th>Task 4</th>
<th>Task 5</th>
<th>Task 6</th>
<th>Task 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>22&quot;</td>
<td>189&quot;</td>
<td>84&quot;</td>
<td>20&quot;</td>
<td>190&quot;</td>
<td>38&quot;</td>
<td>24&quot;</td>
</tr>
<tr>
<td>S2</td>
<td>12&quot;</td>
<td>55&quot;</td>
<td>49&quot;</td>
<td>14&quot;</td>
<td>121&quot;</td>
<td>24&quot;</td>
<td>57&quot;</td>
</tr>
<tr>
<td>S3</td>
<td>30&quot;</td>
<td>62&quot;</td>
<td>150&quot;</td>
<td>160&quot;</td>
<td>60&quot;</td>
<td>40&quot;</td>
<td>24&quot;</td>
</tr>
<tr>
<td>S4</td>
<td>14&quot;</td>
<td>131&quot;</td>
<td>110&quot;</td>
<td>133&quot;</td>
<td>Fail</td>
<td>34&quot;</td>
<td>78&quot;</td>
</tr>
<tr>
<td>S5</td>
<td>18&quot;</td>
<td>197&quot;</td>
<td>Fail</td>
<td>90&quot;</td>
<td>Fail</td>
<td>72&quot;</td>
<td>34&quot;</td>
</tr>
<tr>
<td>S6</td>
<td>12&quot;</td>
<td>Fail</td>
<td>Fail</td>
<td>15&quot;</td>
<td>Fail</td>
<td>24&quot;</td>
<td>22&quot;</td>
</tr>
<tr>
<td>S7</td>
<td>17&quot;</td>
<td>77&quot;</td>
<td>110&quot;</td>
<td>33&quot;</td>
<td>Fail</td>
<td>57&quot;</td>
<td>15&quot;</td>
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<tr>
<td>S8</td>
<td>48&quot;</td>
<td>70&quot;</td>
<td>Fail</td>
<td>124&quot;</td>
<td>Fail</td>
<td>18&quot;</td>
<td>Fail</td>
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<tr>
<td>S9</td>
<td>30&quot;</td>
<td>201&quot;</td>
<td>160&quot;</td>
<td>61&quot;</td>
<td>Fail</td>
<td>227&quot;</td>
<td>48&quot;</td>
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<tr>
<td>S10</td>
<td>13&quot;</td>
<td>115&quot;</td>
<td>Fail</td>
<td>25&quot;</td>
<td>Fail</td>
<td>20&quot;</td>
<td>Fail</td>
</tr>
<tr>
<td>S11</td>
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<td>Fail</td>
<td>Fail</td>
<td>20&quot;</td>
<td>80&quot;</td>
<td>15&quot;</td>
<td>32&quot;</td>
</tr>
<tr>
<td>S12</td>
<td>25&quot;</td>
<td>69&quot;</td>
<td>197&quot;</td>
<td>26&quot;</td>
<td>117&quot;</td>
<td>81&quot;</td>
<td>Fail</td>
</tr>
</tbody>
</table>

* We judged as a failure if a subject gave up the task or could not complete the task within five minutes.

Figure 1 indicates the proportions of successful task completion, which represent the effectiveness of the system. All the subjects successfully completed Task 1, 4, and 6, but only 58.3% and 41.7% of subjects achieved Task 3 and 4 respectively.

Figure 2. Satisfaction level by task (7-point scale)

Finally, Pearson r correlation coefficients were calculated among these three usability elements (Table 2). The usability elements are highly correlated with each other, in particular, the correlation coefficient between effectiveness and satisfaction was 0.889.

Table 2. Correlation analysis among efficiency, effectiveness, and satisfaction

<table>
<thead>
<tr>
<th></th>
<th>Effectiveness</th>
<th>Efficiency</th>
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<tbody>
<tr>
<td>g</td>
<td>.624 *</td>
<td>.736 *</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>.889 *</td>
<td>.736 *</td>
</tr>
</tbody>
</table>

p<.01

CONCLUSION
This study assessed the usability of an academic digital library using three elements: efficiency, effectiveness, and satisfaction. More important, the correlation between these usability elements was analyzed. High correlation coefficients were observed between usability elements exceeding 0.6. Especially, the correlation coefficient between effectiveness and satisfaction was extremely high (r=.889). This result strongly illustrates the highly correlated nature of usability elements. Also, this result could yield theoretical implications in relation to usability assessment models in the digital library area. As the correlation between effectiveness and satisfaction is extremely high, we might be able to come up with a parsimonious usability assessment model that eliminates overlapping elements in measuring the usability of digital library.

REFERENCES