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Evaluating Design Patterns of Commercial Web Applications using Net Easy Score

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Abstract— Web interface design patterns provide solutions to recurring design problems. Many design patterns use various techniques, which have been proven to be significantly different, to solve the same design problem. Normally, web designers do not know whether users would be satisfied with their chosen choice until near or at the end of the web development process. To obtain user feedback, users are usually asked to interact with a web prototype or the finished web and give their opinion through standardized questionnaires. Net Promoter Score is one of such questionnaires. This scale categorizes users' responses into promoters and detractors, which makes it easier for companies to understand user satisfaction towards their web. To enable the designers to obtain user feedback early in the design stage, Net Easy Score, a new metric based on Net Promoter Score, was proposed. With Net Easy Score (NES), ease-of-use scores on different design patterns will be divided into a positive and a negative group. The NES is a difference between percentages of positive responses and negative ones. This study examined ease-of-use scores on design patterns for five common tasks in commercial web applications. Results showed that NES and mean ease-of-use score were significantly correlated with an r of 0.965 ($p < .000$). Also, ranking the average ease-of-use scores and NES revealed the same design patterns identified as the best and the worst ones, which was consistent with the easiest-to-use design patterns voted by participants.

Index Terms— UI Pattern Evaluation, UI Pattern, User Interface Design Pattern, Net Easy Score, Usability Questionnaire

I. Introduction

Design patterns describe successful solutions for recurring design problems. They are an important tool for knowledge sharing to avoid reinventing the wheel in various fields e.g. architecture, software engineering, human-computer interaction [1, 2, 3, 4, 5]. In terms of web application design, there are a number of user interface design patterns (UIDP) that are usually grouped based on tasks or functions, for example, input form, navigation, searching, being social. Each UIDP is normally composed of four parts: context, problem, solution, and examples of screen shots. The first three parts are usually presented in a descriptive format. A design pattern category normally contains several UIDPs, offering statistically significantly different solutions and techniques to the same design problem [6]. With a wide selection of UIDPs, it is not easy for novice designers or anyone who is not familiar with UIDP to know which UIDP is appropriate for their intended users [7, 8].

In a typical web development process, the web usability and user satisfaction evaluation is performed after the development is completed or nearly completed using standardized usability questionnaires [9]. Some questionnaires contain multiple questions for measuring overall satisfaction such as the Software Usability Scale (SUS) [10]. Some ask just a single question. Tedesco and Tullis [11] found that a single question is as good as or better than multiple questions in gathering post-task subjective satisfaction. The problem with the usability test process is that it requires a lot of time and money. Moreover, it is not easy to interpret and apply the usability test results for choosing appropriate web design patterns at the design stage.

Therefore, Net Easy Score (NES), a new metric to obtain user satisfaction towards the web, was proposed. NES would allow web designers to get user feedback as early as at the design stage. Web designers can have users rate their satisfaction on different UIDPs and employ NES to determine which UIDPs would be the best fit with the target users. NES would help web designers make informed decisions on design patterns choice.

The rest of the paper is organized as follows. Section 2 describes the background of design patterns and usability evaluation considered in this study. In section 3, details of test setup, thirty design patterns and data

collection are presented along with the proposed equation. The experimental data and result analysis and discussion are presented in Section 4 and Section 5, respectively. Finally, the conclusions of this study are summarized in Section 6.

II. Background

2.1 Design Patterns

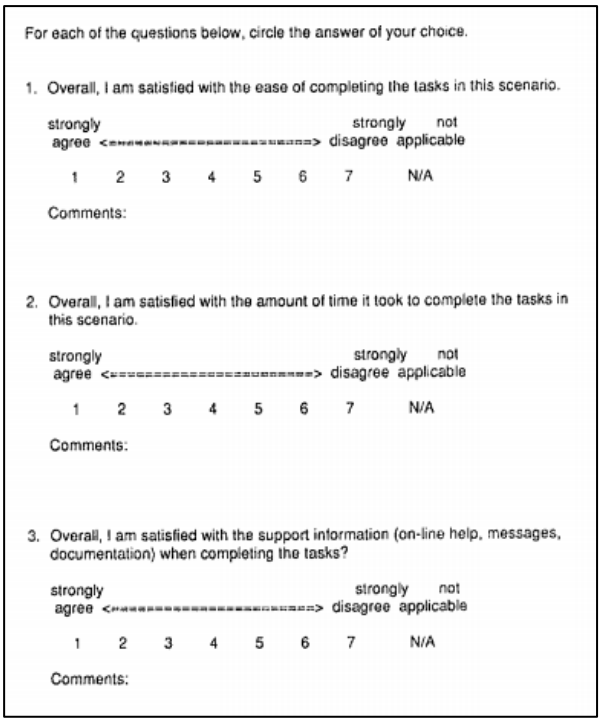
Patterns originated as an architectural concept by Alexander in 1977 [3]. Patterns and pattern languages described best practices, explained good designs, and captured experience in a way that was possible for others to reuse [4, 5, 6, 7]. In 1986, Cunningham and Beck [12] applied Alexander's idea in computer programming and presented the project at a conference called OOPSLA. Design patterns became widely popular after the publishing of Design Patterns: Elements of Reusable Object-Oriented Software, written by the Gang of Four (GoF) in 1994 [4]. In the field of Human-Computer Interaction, Kunert and Kromker [13] proposed a generic hierarchy of design problems and solution alternatives. Based on this hierarchy, they developed generic interaction design patterns that aimed at supporting designers in the exploration and evaluation of design alternatives and their tradeoffs.

Design patterns (DP) have been advocated as a promising technique for achieving reuse of software design knowledge. It has been claimed that design patterns are capable of: 1) Simplifying the design, implementation and maintenance of complex systems, and 2) Improving the quality of software systems. In the field of Software Engineering (SE) and Human-Computer Interaction (HCI), it is widely accepted that a pattern is a structured description of an invariant solution to a recurrent problem in a context [14]. Seffah mentioned that a pattern should provide concrete solutions to problems while being abstract enough to be applied to different situations [8]. Bayle et al. [15] distinguished between design patterns and activity patterns. On the other hand, Grill et al. did not distinguish between design patterns and other patterns in terms of the solution. They simply stated, "a pattern needs to have a proven solution" [16]; thus a pattern cannot be called a pattern until its solution is proven.

For the development of web applications, there is a large collection of web design patterns for web designers to choose from, for example, [5, 17, 18, 19, 20, 21, 22]. These repositories of web design patterns have advantages and disadvantages. Obviously, these collections of web design patterns are an essential knowledge base that the web designers can explore, learn, and apply suitable design patterns. On the other hand, too many choices can lead to confusion, especially for inexperienced web designers. To our knowledge, there is no research that addresses methods for evaluating design patterns at the design stage.

2.2 Usability Evaluation: Single Ease Question and Net Promoter Score ™

The first standardized usability questionnaires appropriate for usability testing appeared in the late 1980s [23, 24, 25]. Some questionnaires were designed for the usability test at the end of a study while others were for a quick and more contextual assessment at the end of each task or scenario. Assessing the perception of usability after completing a set of test scenarios is widely used in national and international standards [26, 27] e.g. After-Scenario Questionnaires (ASQ) [25, 29], Expectation Ratings (ER) [28], Usability Magnitude Estimation (UME) [30], Single Ease Question (SEQ) [31, 32], Subjective Mental Effort Question (SMEQ) [33]. Fig. 1 to Fig. 5 show an example of each questionnaire.


For each of the questions below, circle the answer of your choice.

1. Overall, I am satisfied with the ease of completing the tasks in this scenario.

strongly agree <==========> strongly disagree not applicable

1 2 3 4 5 6 7 N/A

Comments:

2. Overall, I am satisfied with the amount of time it took to complete the tasks in this scenario.

strongly agree <==========> strongly disagree not applicable

1 2 3 4 5 6 7 N/A

Comments:

3. Overall, I am satisfied with the support information (on-line help, messages, documentation) when completing the tasks?

strongly agree <==========> strongly disagree not applicable

1 2 3 4 5 6 7 N/A

Comments:

Fig. 1: The standard ASQ

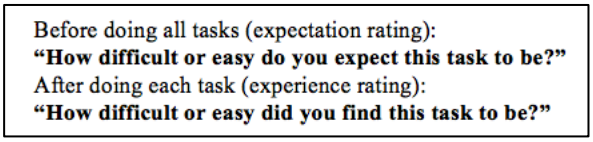

Before doing all tasks (expectation rating):
"How difficult or easy do you expect this task to be?"
After doing each task (experience rating):
"How difficult or easy did you find this task to be?"

Fig. 2: The standard ER

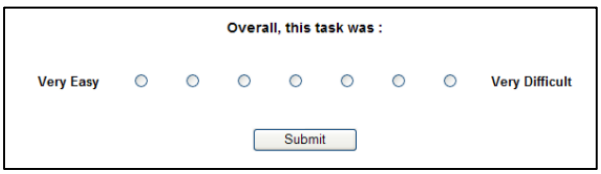


Fig. 3: The standard SEQ

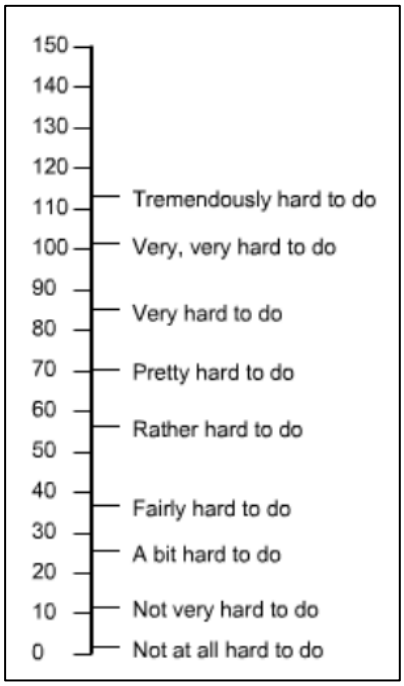


Fig. 4: The standard SMEQ

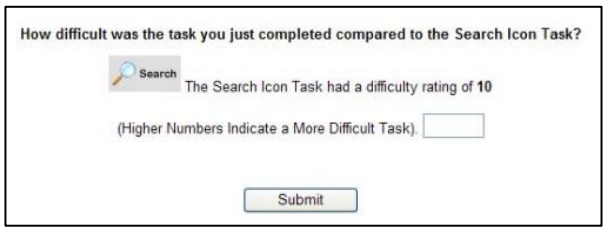


Fig. 5: The standard UME

The website usability may also be assessed with a non-task-related question. A metric called Net Promoter Score [34] uses a single question to measure customer loyalty, i.e. a Likelihood to Recommend question – "How likely is it that you would recommend our company to a friend or colleague?" This question is not related to any particular task. Customers can rate the likelihood on an 11-point scale from 0 (not at all likely) to 10 (extremely likely). Based on the answers, respondents are grouped into promoters, detractors, and passives. Promoters are respondents who select a 9 or 10. Those who select 0 through 6 are detractors and all others are passives. The net promoter score is obtained by calculating the difference between the percentage of promoters and the percentage of detractors. Essentially, this score can be adapted for the website usability assessment. Users can be asked to rate their likelihood to recommend a website to their friends. In other words, this score can be used to indirectly evaluate the usability of a website. A study [9] found that scores of NPS and SUS had a positive correlation of 0.623. This result was based on data collected from lab-based usability tests and surveys of recent product purchases of rental car companies, financial applications, and website like Amazon.com.

III. Methodology

3.1 Test Setup and Design Patterns

Design patterns for web applications are countless [17, 18, 19, 20, 21, 22]. In this study, we focused on design patterns for five common functions of commercial web applications, i.e. 1) search box and autocomplete 2) registration 3) interaction with search results 4) edit posted advertisement and 5) pagination. For each function, six design patterns that are widely used in commercial websites were selected. Details of thirty design patterns used in this study are shown in Table 2. The screen shot of each design pattern is displayed in the Appendix.

3.2 Test Setup and Data Collection

A high-fidelity prototype of each design pattern was developed. All thirty prototypes, as well as the task difficulty questionnaire, were hosted on an Amazon cloud server to ensure that the test environment was the same to all participants. Each participant was asked to sit down in front of a PC, interact with all six prototypes of one web function and evaluate the ease of use of each design pattern on a 7-point rating scale (1 = very difficult, 2 = difficult, 3 = slightly difficult, 4 = fair, 5 = slightly easy, 6 = easy, and 7 = very easy) via an online questionnaire. Participants were also asked to indicate the easiest-to-use design pattern among the six prototypes. Number of participants testing design patterns in each group and their characteristics are shown in Table 1.

Table 1: Number of participants & participant characteristics

Task Name	Number of participants	
Search box	32	
Registration	41	
Interaction with Results	39	
Edit Post	32	
Pagination	40	
Characteristics	**Participants**	
	N	**%**
Gender		
Male	45	24%
Female	139	76%
Age		
Less than 21 years old	35	19%
21 to 30 years old	118	64%
31 to 40 years old	12	7%
Older than 50 years old	18	10%
Not specific	1	1%
Education		
Lower than bachelor's degree	12	7%
Bachelor's Degree	152	83%
Master's Degree	18	10%
Not specific	2	1%

3.3 Evaluation Using the Proposed Net Easy Score

Based on Net Promoter Score, Net Easy Score (NES) was proposed. A group of participants who voted 6 - 7 were defined as the "Positive" whereas those who rated 4-5 and 1-3 were defined as the "Neutral" and the "Negative", respectively. To calculate Net Easy Score, we subtracted the percentage of the negative from the percentage of the positive as shown in (1). Net Easy Score has a range from -100% to +100%.

NES (%) = % of the positives – % of the negatives (1)

The results from NES were then compared with the average ease-of-use scores.

Table 2: Design patterns for five common tasks of commercial web applications

Task Name	Design Patterns
Search box and autocomplete	S_DP1 - Simple search box S_DP2 - Search box with 1 drop-down menu S_DP3 - Search box with 2 drop-down menus S_DP4 - Search box with autocomplete feature S_DP5 - Search box with autocomplete feature and picture S_DP6 - Search box with autocomplete feature and rating score
Registration	R_DP1 - Lazy Form R_DP2 - Full form displayed in multiple pages R_DP3 - Full form displayed in 1 page R_DP4 - Login with social network account R_DP5 - Short form with post details R_DP6 - Full form with post details
Interaction with Search Results	I_DP1 - Click to see details I_DP2 - Mouse over to see short details I_DP3 - Click to see short details with sliding pictures I_DP4 - Click to see short details with clickable thumbnail pictures I_DP5 - Click to see short details with mouse-over action to change pictures I_DP6 - Click to see short details, mouse over to change pictures with Add to Wish List button
Edit Posted Ad	E_DP1 - Go to my account, my post, then select to edit E_DP2 - Click my ad, then select to edit E_DP3 - Mouse over to see popped-up my list and click to edit E_DP4 - Mouse over to see my ad and click edit icon to edit E_DP5 - Inline edit E_DP6 - Click from my last ad area to edit
Pagination	P_DP1 - Show page number with next and previous button P_DP2 - Show next and previous button without page number P_DP3 - Show groups of page numbers with next and previous button P_DP4 – Automatically show more results on the same page when mouse moves to the bottom of result page P_DP5 - Show "see more results" button and click to extend the result area on the same page P_DP6 - Drag slider bar to see more results and extend the result area on the same page

IV. Results

Table 3 shows number of times a design pattern was rated for each score on a 7-point rating scale in percentage. It also shows number of users who voted the easiest-to-use design pattern for each design pattern. Most design patterns which participants rated 7 (very easy) were also voted for the easiest-to-use design pattern. For the search box and autocomplete function, DP5 obtained the highest percentage of score 7 and was rated as the easiest-to-use design pattern. The design pattern rated as the easiest-to-use for other design pattern group is as follows: DP4 for registration, DP6 for interaction with results, DP5 for editing posted advertisement, and DP1 for pagination. The average ease-of-use score and NES for each design pattern are displayed in Table 4. A Pearson correlation analysis revealed that the average ease-of-use score and NES score have a strong positive relationship with an r of 0.965 (p value < 0.000). These design patterns were also ranked based on the two scores. Results were consistent across all scores, as shown in Table 5.

- For the search box and autocomplete function, all ranks showed DP5 as the best solution whereas they showed DP3 as the worst solution. However, three design patterns received the same number of votes for the easiest-to-use design pattern: DP3, DP4, and DP6.
- For the registration task, DP4 was ranked the best solution while DP3 was ranked the worst solution. The number of votes for the easiest-to-use design pattern was equal between DP2 and DP3.
- For the interaction with search results group, the best and the worst solution were DP6 and DP2, respectively.
- For the group of design patterns related to editing posted advertisements, DP5 was rated the best solution and DP1 the worst solution. However, DP3 was voted for the easiest-to-use design pattern.
- For the pagination design patterns group, all ranks showed DP1 and DP2 as the best and the worst solution, respectively.

Table 3: Number of times each design pattern was rated for each score (in percentage) and number of users who voted the easiest-to-use design pattern for each design pattern

Pattern ID	Ease of Use Rating (%)							The easiest-to-use design pattern
	1	2	3	4	5	6	7	
S_DP1	9.38	6.25	18.75	21.88	31.25	9.38	3.13	6
S_DP2	3.13	12.50	18.75	31.25	21.88	12.50	0	3
S_DP3	9.38	31.25	21.88	18.75	6.25	6.25	6.25	2
S_DP4	0	0	3.13	18.75	37.50	25.00	15.63	2
S_DP5	0	0	3.13	21.88	12.50	25.00	37.50	17
S_DP6	0	0	9.38	34.38	31.25	21.88	3.13	2
R_DP1	0	4.88	4.88	34.15	19.51	26.83	9.76	9
R_DP2	0	7.32	21.95	26.83	21.95	19.51	2.44	1
R_DP3	0	7.32	29.27	43.90	12.20	7.32	0	1
R_DP4	0	2.44	14.63	17.07	17.07	24.39	24.39	21
R_DP5	0	7.32	19.51	24.39	31.71	9.76	7.32	4
R_DP6	0	19.51	24.39	21.95	19.51	12.20	2.44	5
I_DP1	2.56	5.13	20.51	28.21	28.21	12.82	2.56	4
I_DP2	0	2.56	17.95	46.15	23.08	10.26	0	3
I_DP3	0	2.56	23.08	33.33	25.64	10.26	5.13	4
I_DP4	0	5.13	12.82	25.64	38.46	5.13	12.82	4
I_DP5	0	2.56	12.82	17.95	38.46	23.08	5.13	5
I_DP6	0	0	7.69	17.95	38.46	20.51	15.38	19
E_DP1	9.38	15.63	25.00	34.38	6.25	6.25	3.13	2
E_DP2	3.13	0	25.00	37.50	28.13	6.25	0	2
E_DP3	0	3.13	25.00	40.63	31.25	0	0	1
E_DP4	0	0	15.63	37.50	31.25	12.50	3.13	5
E_DP5	0	0	3.13	9.38	34.38	28.13	25.00	20
E_DP6	0	0	15.63	50.00	18.75	15.63	0	2
P_DP1	0	0	2.50	27.50	30.00	17.50	22.50	13
P_DP2	0	10.00	25.00	35.00	22.50	7.50	0	0
P_DP3	0	5.00	10.00	32.50	32.50	17.50	2.50	7
P_DP4	0	0	15.00	25.00	22.50	15.00	22.50	10
P_DP5	5.00	0	25.00	25.00	17.50	17.50	10.00	6
P_DP6	0	10.00	17.50	30.00	17.50	17.50	7.50	4

Table 4-1: Average ease-of-use score and NES for each design pattern with ranking

Pattern ID	Avg. Score	Std. Dev.	% of Positive	% of Negative	NES Score	NES Rank	Avg. Score Rank	Remarks
S_DP1	4.00	1.52	12.50	56.25	-43.75	4	4	
S_DP2	3.94	1.32	12.50	65.63	-53.13	5	5	
S_DP3	3.25	1.65	12.50	81.25	-68.75	6	6	The worst
S_DP4	5.31	1.06	40.63	21.88	18.75	2	2	
S_DP5	5.72	1.28	62.50	25.00	37.5	1	1	The best
S_DP6	4.75	1.02	25.00	43.75	-18.75	3	3	
R_DP1	4.88	1.29	36.59	43.90	-7.32	2	2	
R_DP2	4.32	1.29	21.95	56.10	-34.15	4	4	
R_DP3	3.83	1.00	7.32	80.49	-73.17	6	6	The worst
R_DP4	5.20	1.49	48.78	34.15	14.63	1	1	The best

Table 4-2: Average ease-of-use score and NES for each design pattern with ranking

Pattern ID	Avg. Score	Std. Dev.	% of Positive	% of Negative	NES Score	NES Rank	Avg. Score Rank	Remarks
R_DP5	4.39	1.32	17.07	51.22	-34.15	3	3	
R_DP6	3.88	1.40	14.63	65.85	-51.22	5	5	
I_DP1	4.23	1.29	15.38	56.41	-41.03	4	5	
I_DP2	4.21	0.95	10.26	66.67	-56.41	6	6	The worst
I_DP3	4.33	1.18	15.38	58.97	-43.59	5	4	
I_DP4	4.64	1.31	17.95	43.59	-25.64	3	3	
I_DP5	4.82	1.17	28.21	33.33	-5.13	2	2	
I_DP6	5.18	1.14	35.90	25.64	10.26	1	1	The best
E_DP1	3.44	1.44	9.38	84.38	-75	6	6	The worst
E_DP2	4.06	1.05	6.25	65.63	-59.38	4	4	
E_DP3	4.00	0.84	0.00	68.75	-68.75	5	5	
E_DP4	4.50	1.02	15.63	53.13	-37.5	2	2	
E_DP5	5.63	1.07	53.13	12.50	40.63	1	1	The best
E_DP6	4.34	0.94	15.63	65.63	-50	3	3	
P_DP1	5.30	1.18	40.00	30.00	10	1	1	The best
P_DP2	3.93	1.10	7.50	70.00	-62.5	6	6	The worst
P_DP3	4.55	1.13	20.00	47.50	-27.5	3	3	
P_DP4	5.05	1.40	37.50	40.00	-2.5	2	2	
P_DP5	4.43	1.53	27.50	55.00	-27.5	4	4	
P_DP6	4.38	1.43	25.00	57.50	-32.5	5	5	

V. Discussion

The strong relationship between average ease-of-use score and NES was expected. Essentially, the two scores summed up the same raw data in different approaches. However, NES can be graphically presented as shown in Fig. 6. This graphical representation could help web designers easily distinguish between good and bad design patterns. The study's findings revealed that the proposed NES can be used as a tool for usability evaluation.

Although web designers can use average ease-of-use scores or NES to determine which design patterns are perceived as easy to use by users, they do not really know reasons why one design pattern is preferred to the other design pattern. These two scores merely tell users' perception without much offering details why users perceive one design pattern easier to use than other design patterns. New metrics are needed to fill this gap.

Table 5: The best and worst design pattern in each category based on average ease-of-use score, the easiest-to-use DP vote, and NES

Type	Task Name	Average Score	The easiest voted DP	NES
The best	Search box	DP5	DP5	DP5
	Registration	DP4	DP4	DP4
	Interaction with Results	DP6	DP6	DP6
	Edit Post	DP5	DP5	DP5
	Pagination	DP1	DP1	DP1
The worst	Search box	DP3	DP3, 4, 6	DP3
	Registration	DP3	DP2, 3	DP3
	Interaction with Results	DP2	DP2	DP2
	Edit Post	DP1	DP3	DP1
	Pagination	DP2	DP2	DP2

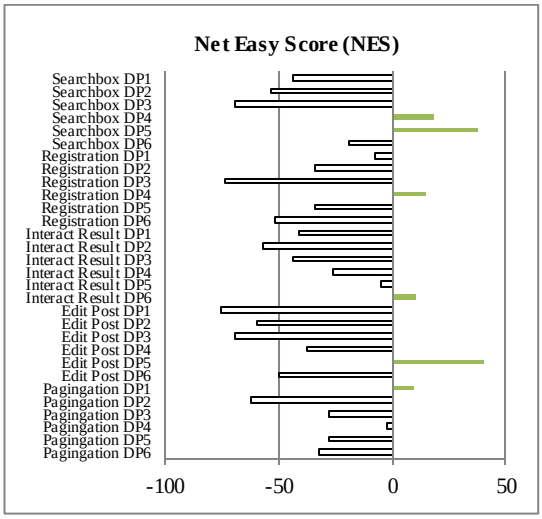


Fig. 6: NES graphical represent the outstanding net of the positive score

VI. Conclusion

This study proposed Net Easy Score (NES), conceptually based on Net Promoter Score, as another usability metric to help web designers easily obtain user feedback on the designs. NES divides users' responses to a single question into the positive, the neutral, and the negative group. A question asked participants to rate the ease of use of a design pattern on a 7-point scale from 1 (very difficult) to 7 (very easy). Average ease-of-use score and NES were computed for each design pattern. Each design pattern was also ranked according to these scores. Results revealed that average ease-of-use score, NES, and the easiest-to-use design pattern are related. Most design patterns that were voted the easiest-to-use received the highest average ease-of-use score and the highest positive NES. The study's findings suggest that any of these scores could be reasonable "surrogates" used to identify design patterns that users had difficulty working with, particularly when it may not be practical to collect performance data.

In sum, NES can be a valuable addition to the family of usability metrics. It provides additional diagnostic information that post-task questionnaires do not provide. It also does not take much time to obtain the data. Future works should be conducted with complete web applications or real situation of design pattern use. More participants other than Thais should also be included.

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Appendix

The screen shots of each design pattern detailed in Table 1 are displayed below.

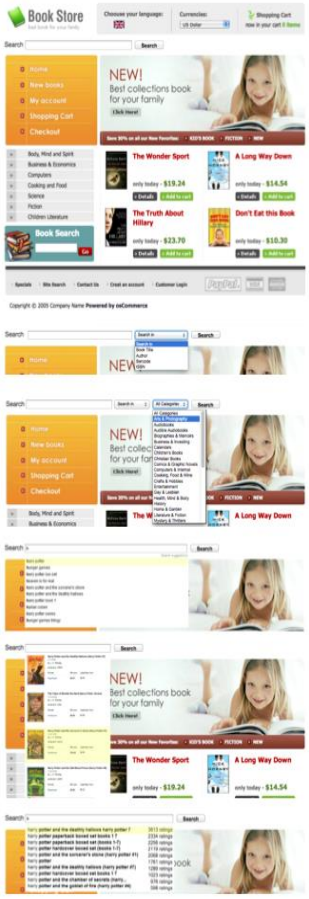

Fig. A-1: Six-design solutions of search box and autocomplete

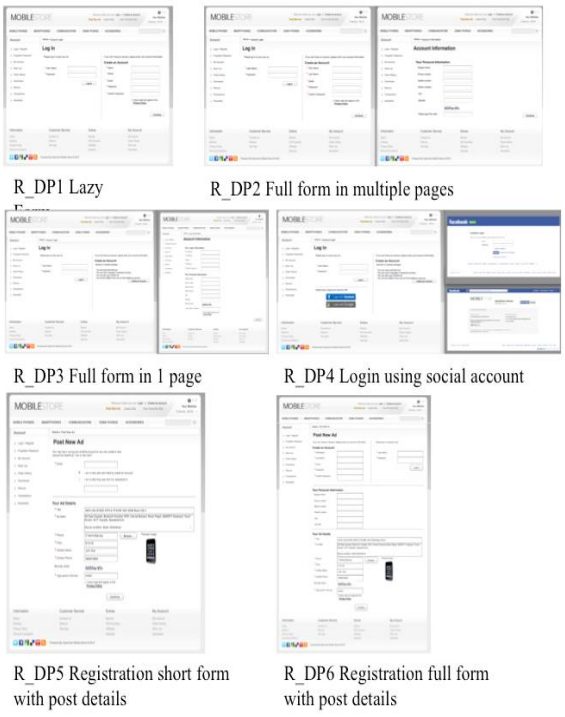

Fig. A-2: Six-design solutions of registration

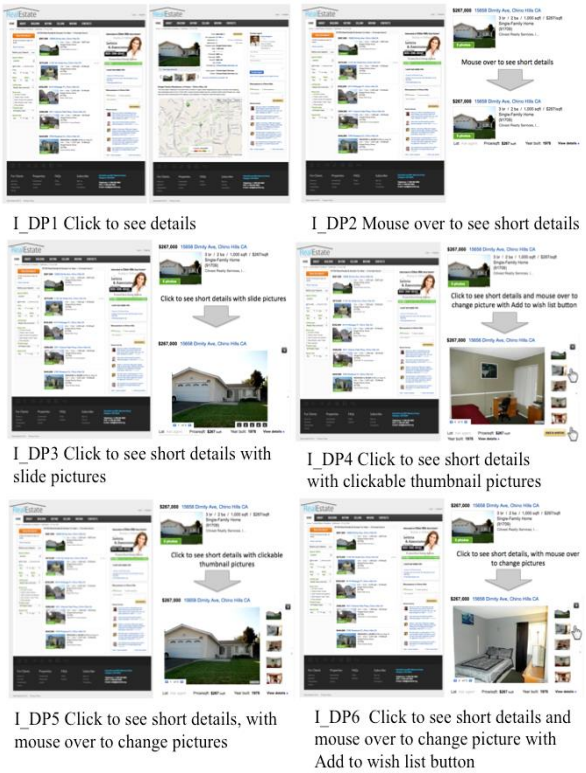

Fig. A-3: Six-design solutions of interaction with results

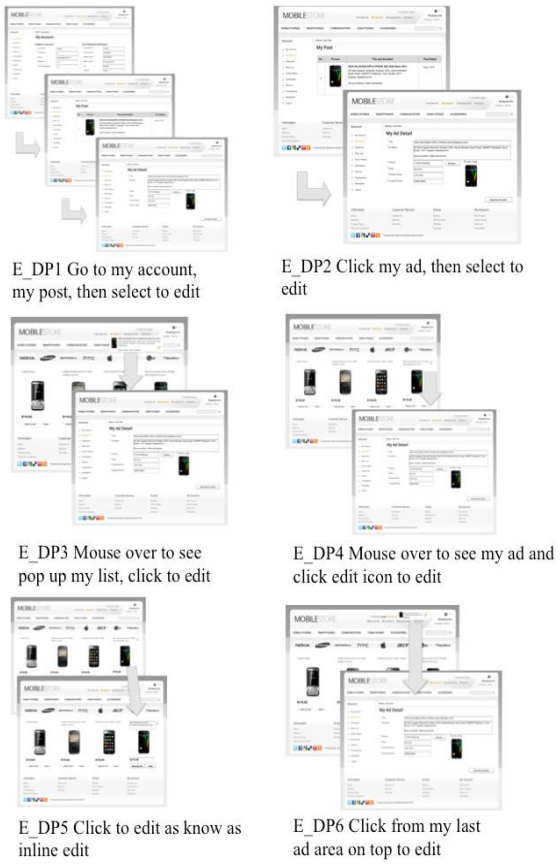

Fig. A-4: Six-design solutions of edit posted advertisement

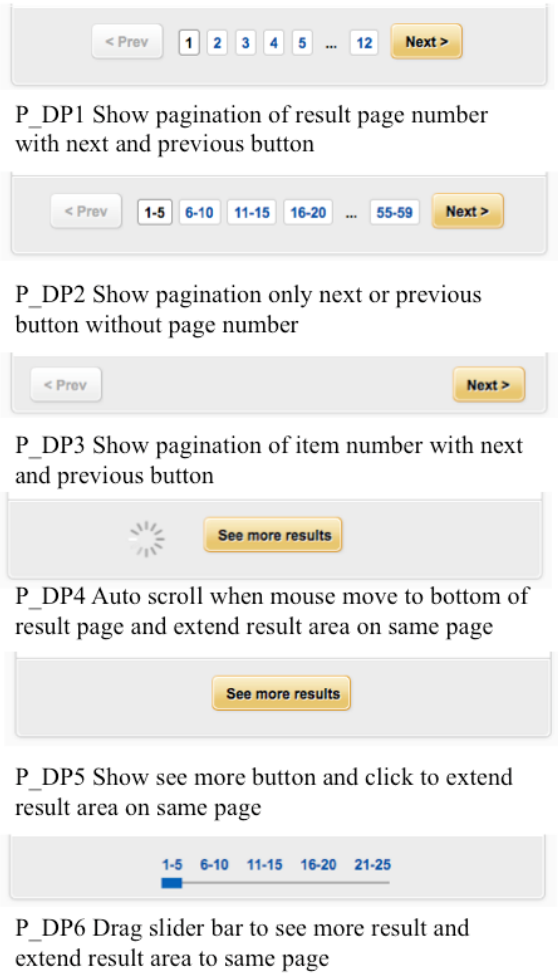

Fig. A-5: Six design solutions of pagination

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