Quality Assessment of Web and APP Design Patterns

Yi-Qi Chen, Sun-Jen Huang, Yu-Hsiang Chien, and I-Ting Hsiao

Abstract—To respond to the needs of platform users on mobile devices in recent years, several types of web and mobile application software design patterns, including responsive web design (RWD), adaptive website design (AWD), Separate URLs (M.dot), and mobile application software (APP) have been proposed. However, it is difficult for platform owners and developers to decide which design pattern is suitable for them. Therefore, this study explored the literature on the quality assessment indicators of websites and web applications and proposed three quality facets based on the quality inspection project of the website of the National Development Council (NDC). There were three quality facets and a total of 14 quality indicators. This study further chose six sample platforms of three types of social media, news media, and e-commerce based on the network traffic analysis platform. After evaluation and testing, this study analyzed the evaluation results of different design patterns for each sample platform and then discussed each design pattern and its overall comparison. According to the analysis results of an individual design pattern, APP design patterns are recommended for the platforms whose quality requirements are functional applications, loading response speed, and user experience. AWD design patterns are recommended for the platforms whose quality requirements are information connectivity and interface design and layout. RWD design patterns are recommended for the platforms whose quality requirements are platform visibility and information connectivity. If an existing platform has already developed traditional web design and it's difficult to adjust greatly, the alternative of increasing the development of M.dot is recommended.

Index Terms—responsive web design, adaptive website design, M.dot, mobile application software, quality evaluation indicators

I. INTRODUCTION

The development of Web Application Software (WAS) has evolved from desktop to the era of multi-screen. Nowadays, the main carriers include desktop, notebook, tablet, and smartphone. However, to provide a good user experience (UX) for web application users, several web design patterns have been proposed one after another, including M.dot, Responsive Web Design (RWD), and Adaptive Web Design (AWD) (Chih-Yuan Hung, 2016)[1].

Responsive Web Design (RWD) gradually leads the trend of design patterns, keeping the same URL and code for any device on which the web is viewed, regardless of the desktop, tablet, and mobile (Chih-Yuan Hung, 2016) [1]. The layout is adjusted to fit the screen size, but the content displayed on different devices is still the same and uses the same CSS.

Adaptive Web Design (AWD) not only takes RWD technology to control the page layout on the client side but also designs different CSS for different types of carriers to display the corresponding web pages according to the detected user carrier device and resolution size.

In order to provide user-friendly layouts, for the platform mainly based on traditional desktop websites, considering the conversion cost, the design pattern (defined as M.dot in this study) creating a separate version of the website came along. With detecting the type of device first, and then redirected to the corresponding version with a separate URL.

However, due to some unachievable functions of web browsers, such as hardware support, mobile application software (APP) has emerged, which refers to third-party applications. Compared to the first three types of platform developments, it's a more independent platform design pattern. It's not limited by the browser, moreover, it is an application software system that can be integrated with the mobile system in smartphones.

Most works have been presented solely studying RWD, mainly focused on UI, usability, and adoption behavior (Chih-Yuan Hung, 2016)[1]. In recent years, previous research studied RWD and APP by technology acceptance models or discussed the factors of people using government websites from the view of usability or just comparing RWD and non-RWD web design (desktop and mobile individually). However, very few studies have reported on responsive web design (RWD), adaptive web design (AWD), mobile web design (M.dot), and mobile application software (APP) (Ming-Heng Lai, 2017)[2]. In this paper, we focus on four web and mobile application design patterns, Responsive Web Design (RWD), Adaptive Web Design (AWD), Mobile Web Design (M.dot), and Mobile Application Software (APP). The purpose is to explore the most suitable design pattern for different platform types and also to discover the strengths and weaknesses of quality facets and assessment indicators of each web and APP design pattern. This research is to provide suggestions for platform developers to choose the appropriate design pattern according to the needs of different indicators of the platform and also the project time and cost considerations.

II. RELATED WORK

To define indicators for quality assessment, we found relevant studies on (1) software quality evaluation and (2) user interface design pattern quality decision, including Government Website Service Management Specifications, software quality model, factors for evaluation of multiple platforms, and indicators for web quality evaluation

A. Indicators for Website Quality Assessment

We summarized indicators fitting the three facets in this research (Information Service, System Usability, and System Design) by finding relevant research on the indicators used to evaluate website quality and considering commonly-and-frequently-used indicators, which are formatted in bold style in Table I.

TABLE I: INDICATORS FOR THE ASSESSMENT OF WEBSITE QUALITY.

Facet	Indicator	Reference
Information service	Usefulness(Informative/ Functionality/ Service), Collaborative Interactivity, Waiting Time, **Page Load Speed(4)**, Information Service Quality, **Search Functionality(3)**, Compatibility, **Multimedia Application(3)**, Interactive Features(4), Functional Quality, Website Service Visionary Design) , Animation	Deng-Hau Chen(1996)[3], Tsu-Feng Ho et al.(1998)[4], Gehrke et al.(1999)[5], Liu et al.(2000)[6], Chao(2002)[7], Kim et al.(2002[8]), Zhang, P. et al.(2002)[9], Guan-Ting Ho(2006)[10], Tsai, W.H. et al.(2010), National Development Council(2013)[11], National Development Council(2019)[11], Cheng-Yin Tsai et al.(2008)[12], Chun-Hui Chang(2013)[13]
System usability	Efficiency, Subjective Satisfaction, Ease of Using(Abilities learners should equip/System User Interface), User Research, Efficiency of Navigation, Usability(Design/ Reaction time/Intuition), System Usability, **Ease of Browsing(3)**, Availability, Operability	Jakob(1993), Deng-Hau Chen(1996)[3], Tsu-Feng Ho et al.(1998)[4], Huey-jiuan Ueng(1998), Gehrke et al.(1999)[5], Eleanor T. Loiacono(2000), Liu et al.(2000)[6], Chao(2002)[7], Zhang, P. et al.(2002)[9], Tarafdar,et al.(2006), Cheng-Yin Tsai et al.(2008)[12]
System design	Aesthetics(Figures and Animation/Layouts), **User Interface Design(5), Navigation Architecture Design of Resource Classification(4)**, System Design Quality, URL Availability of Information Navigation**(7)**, **Layout(3)**, Design Quality, Route Linking Function, RWD Design	Deng-Hau Chen(1996)[3], Tsu-Feng Ho et al.(1998)[4], Huey-jiuan Ueng(1998), Liu et al.(2000)[6], Chao(2002)[7], Wen-Chi Lin et al.(2002), Ouyang Chung-jang et al.(2006), Tsai, W.H. ,et al(2010), National Development Council(2013)[11], National Development Council(2019)[11], Chun-Hui Chang(2013)[13]

B. National Development Council Inspection Criteria and Scoring

This paper outlines a method for evaluating quality indicators using the National Development Council (NDC) Inspection Criteria for scoring government websites.

The National Development Council (NDC) revised the Government Website Operational Performance Appraisal Plan in March 2019, resulting in 8 key indicators and 34 sub-indicators. The assessment of these indicators is customized to the specific business attributes of different government agencies, with portals classified as type (I) and business-oriented or themed-oriented sites classified as type (II). Table II in this paper outlines the key indicators, sub-indicators, criteria, and scoring methods used.

III. RESEARCH DESIGN

The research method of this study can be divided into four stages, as shown in Fig. 1.
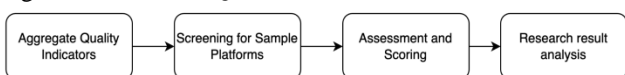

Fig. 1. The research process of this paper.

A. Aggregate Quality Indicators

This paper collects indicators commonly used to assess quality based on literature research. We have chosen 14 indicators based on three important facets (Information Service, System Usability, and System Design). These indicators will be thoroughly explained in Section 4.

B. Screening for Sample Platforms

After aggregating indicators, we use the network traffic analysis platform, Alexa, to seek sample platforms. It's a platform that is able to reveal the regional website rank by monitoring worldwide domains and analyzing the big data.[2] We select popular platforms among domestic users and wrap up platform types suitable for assessing web pages and APP design patterns.

We initially choose the top 30 platforms in Taiwan (by April 30, 2019), and after summarizing and classifying platforms that are popular among domestic users, we obtain ten platform types: search engines, video media, social media, news media, portals, e-commerce, online encyclopedias, human banking, community forums, and blogs.

We narrow down selected platform types according to if the type is abundant with many design patterns. For example, we first choose "News media " to be in the sample platforms since it is the one covering four web design patterns the most. Subsequently, "Social Media," "E-commerce," "Community Forum," and "Blog" are considered as the follow-up considerations since most of the platforms of these types cover at least two design patterns.

Since the platform characteristics of "social media" and "blog" are similar, we choose the previous one to be the sample platform considering its popularity and adaptability. Lastly, we include "E-commerce" in the sample platform type as well since its user count is considerable and is very unique regarding its characteristics.

TABLE II: THE GOVERNMENT WEBSITE OPERATIONAL PERFORMANCE APPRAISAL PLAN

Indicator	Sub-indicator	Definition	Score	Criteria
Interface	Navigation (I),(II)	Main component of elements of navigation: (1) Homepage is provided with a sitemap (2)Sitemap.xml is provided (3)Bread crumb trail is provided	4	• 2 points - Homepage is provided with a sitemap • 1 point - Sitemap.xml is provided • 1 point - Bread crumb trail is provided • 0 point - If none are provided
Maintenance management	Link Availability(I),(II)	Availability of the links provided by the website should be guaranteed.	5	• 5 points - All available • 1 point -1 unavailable • 0 point - more than 2 are unavailable
	Animation(I), (II)	Open standards are adopted for website animation and interactive content to ensure users can visit the website with multiple devices, and the Flash document should be removed.	2	• 2 points - No Flash documents are detected • 0 points -Flash documents are detected
Website Service of Innovation	Search Function(I), (II)	The search box should be clearly shown in the layout, and recently released content can be searched.	3	• 3 points - If yes. • 0 points - If no.
Mobile Friendliness	Responsive Web Design (I), (II)	The website should be designed based on RWD to enhance mobile convenience.	5	• 5 points - If designed based on RWD. • 0 points - If not designed based on RWD.
	Page Load Speed (I), (II)	Ensure Page Load Speed so as not to cause a negative influence on user experience.(Test the Page Load Speed by using the tool PageSpeed Insights)	7	• 7 points - If scored over 70. • 5 points - If scored over 50. • 3 points - If scored over 30. • 0 points - If scored less than 30.
Community Service	Sharing(I), (II)	Sharing functions are provided for users to share the website to social media	2	• 2 points - If yes. • 0 points - If none.
	Interaction(I)	Information about the organization's social media accounts is displayed, preferably on the homepage.	3	• 2 points - Information about the organization's social media accounts are displayed on the homepage. • 0 points - Information about the organization's social media accounts is not displayed on the homepage.
Innovation	Website service of innovation (I), (II)	The website's service is user-oriented, including chatbot, crowdsourcing, visual design, etc.	3	• 3 points to the total score - If any of them are provided. (bonus points)
	Traffic Dashboard(I), (II)	The National Development Council dashboard service is added to the website to present government traffic data.	3	• 3 points to the total score - If the dashboard service is added to the website. (bonus points)

Reference: National Development Council(2019)－The Government Website Operational Performance Appraisal Plan[11]

TABLE III: Sample Platforms and Their Design Patterns

Type	Platform	RWD	AWD	M.dot	APP
Social media	Facebook			✓	✓
	Dcard		✓		✓
News media	udn.com	✓		✓	✓
	The Storm Media	✓			✓
e-commerce	Momo			✓	✓
	Shopee		✓		✓

As for sample platforms, with further consideration of the mobile application software, among the top-traffic "social media" platforms, Instagram is excluded since it doesn't meet iOS's definition of a "social" type App. Then, Line is excluded since the significant venues for Line users are mobile applications or desktop software. Therefore, the sample platforms selected for "social media" are "Facebook" and "Dcard".

As for "news media", since it is one of the few types that platforms of it are very commonly designed with RWD, platforms that are designed with RWD techniques, such as SETN (SET News Channel), udn.com, and The Storm Media, are our first choices. Then, we examine the designed patterns adopted by these platforms.

First, The Storm Media is wholly designed with RWD, so it is the first news media platform we selected. Then, we considered ranks on Alexa and mobile application software and found that udn.com is slightly better than others, so the second choice for news media platforms is udn.com.

As for e-commerce, momo.com and Shopee ranked top 2 on both Alexa and mobile application software. Therefore, in this paper, we chose them to be the sample platforms for the platform type, e-commerce.

We ended up with three types of sample platforms. For social media, Facebook and Dcard were chosen. For news media, we decided on udn.com and The Storm Media. As for e-commerce, momo.com and Shopee were selected.

C. Assessment and Scoring

The assessment methods used in this paper can be divided into (1) tool assessment, (2) developer evaluation, and (3) user testing; each indicator is assessed by different methods according to its characteristics. For example, indicators like Platform Visibility and Page Load Speed are scored by tool assessment; Multimedia Application and Interface Design and Layout are scored by developer evaluation; Information Search Usability and Overall Satisfaction are scored by user testing.

This paper focused on assessing (1) four design patterns and (2) selected sample platforms. For the scoring criteria, the total score of each indicator is 7 points. Since we have 14 indicators in this paper, the total score comes to 98 points. The scoring criteria for each indicator are different, the score of each indicator is still 7 points, the same as the others.

Take the Platform Visibility under the Information Service facet as an example; its assessment method is to calculate the SEO score by the tool Awoo SEO, which gives out a minimum score of 0 points and a maximum score of 100.

In this paper, we standardize it to a total score of 7 points. For example, 1~10 points for Awoo SEO corresponds to 1 point; 86~100 points for Awoo SEO corresponds to 7 points. If Awoo SEO fails to assess, 0 points will be given.

Take the Navigation Architecture Design under the System Design facet as an example; the assessment method is to take National Development Council Inspection Criteria as a reference and let the developers evaluate it according to the adjusted criteria applied in this research.

This indicator is scored according to how many types of breadcrumb trails the platform provides. If only one design is provided, 3 points will be given; if two are provided, 5 points will be given; If more than three, 7 points will be given. If none are provided, 0 points will be given.

Take the Information Search Usability under the System Usability facet as an example; this indicator is used to judge if the platform's navigation is of sufficient ease and fluency for users to search for the information they need. The assessment method involves user testing, questionnaires, and user interviews.

By observing scenarios when users use the platform, we can evaluate the fluency and satisfaction of user experience according to their behavior of searching and viewing information on the platform. We can then evaluate the average point the indicator gets; the scoring method refers to Likert 7- point; 1-point indicates strongly disagree. 7-point indicates strongly agree.

D. Research Result Analysis

After the assessment, the quality performance of sample platforms and four design patterns are analyzed. The following two analyses are conducted according to the assessment result:

(1) Quality performance comparison of web and mobile application software design patterns: We first compare and evaluate the performance of four design patterns according to the quality indicators in three facets (Information Service, System Usability, and System Design) and discuss the overall quality performance comparison.

(2) Quality performance comparison of design patterns of

three platform types: We compare the quality performance of design patterns of three platform types: social media, news media, and e-commerce, and conduct a comparative analysis of the results. For more detail, please refer to Section 5.

IV. Quality Assessment Indicators For Web And Mobile Application Design Patterns

A. Classification of Quality Assessment Indicators

After literature review, based on four web and mobile application design patterns in Fig 2, we organized 14 quality assessment indicators for web and mobile application design patterns.

There are a total of 14 quality performance indicators involved in this research. In order to enhance the analysis's feasibility and effectiveness, we then categorized these indicators into three facets based on different angles, such as individual nature, relation, and similarity among indicators.

The three facets are "Information Service Quality," "System Usability Quality" and "System Design Quality". Table IV illustrates the definition of the "Interface Design and Layout" indicator under the facet System Usability Quality. Table V illustrates the definition of the "Navigation Architecture Design" indicator under the facet of System Design Quality. Table VI illustrates the definition of the "Page Load Speed" indicator under the facet of Information Service Quality.

Fig. 2. The Assessment indicators of design pattern -classified by quality facets.

TABLE IV: Definition of "Interface Design and Layout" Indicator

Definition of Indicators		
Browser type	Desktop & Mobile Browser Versions	Mobile application browser
Indicator No.	ID&LO_SDQ_T&S	
Indicator name	Interface Design and Layout	
Indicator purpose	Explore the accessibility of the platform system in terms of text headers, buttons, forms, images and animations, and layout.	

TABLE V: Definition of "Navigation Architecture Design" Indicator

Definition of Indicators		
Browser type	Desktop & Mobile Browser Versions	Mobile application browser
Indicator No.	NAD_SDQ_S	
Indicator name	Navigation Architecture Design	
Indicator purpose	Explore the platform system providing optimized and complete design of the navigation architecture in order to facilitate user navigation and to find the required information through the navigation path.	

TABLE VI: Definition of "Page Load Speed" Indicator

Definition of Indicators		
Browser type	Desktop & mobile Browser Versions	Mobile application browser
Indicator No.	PLS_ISQ06_T&S	
Indicator name	Page Load Speed	
Indicator purpose	Explore the time required for the information on a webpage to users being able to see and interact with the whole content, as well as the time required for the first delay.	

V. Result

A. The Comparison of Overall Quality Performance Toward Web and Mobile Application Design Patterns

1) Effectiveness of quality facets on design pattern

As described in Table VII, in terms of quality facets, the effectiveness of Information Service Quality and System Usability Quality was in the same order as APP, AWD, RWD, and M.dot, which indicates that the satisfaction of user experience is related to the completeness of the information services. Both Functional Application and Page Load Speed have an influence on users' feelings in different design patterns. While the rank of the effectiveness of System Design Quality is AWD, RWD, M.dot, and APP, listed in the order of the best to the worst.

2) The dominant indicators of the design pattern

In terms of the dominant indicators of each design pattern, Platform Visibility, Multimedia Applications, and Information Connectivity were the dominant indicators of RWD, but none of them are significant.

Indicators like Information Search Usability, Information Connectivity, Interface Design and Layout, and Consistency were the dominant indicators of AWD, in which Compatibility (5.5) shows significant superiorities over RWD (0) and M.dot (1.33).

As for Search Function, Interactivity Function, Compatibility, Page Load Speed, Information Search Functionality, Intuitively Operability, Layouts, Overall Satisfaction, Navigation Architecture Design, and Consistency, these indicators were the dominant indicators of APP, in which both Compatibility (6.5) and Page load speed (5.5) indicators show significant superiorities.

However, among the three quality facets, APP (13) has significant weakness compared to RWD (20.67), AWD (23.5), and M.dot (19.33), while in Information Service Quality, APP

(25.5) has significant superiority in the whole group. As for M.dot, there aren't any outstanding performances among the indicators.

3) The aggregate performance towards the whole qualities of design pattern

Aggregating the performance of design patterns adopted by sample platforms, based on the average scores, the order with the best performance to the worst, which is AWD (64.25), APP (60.83), RWD (57.67), and M.dot (53).

TABLE VII: COMPARISON OF OVERALL QUALITY PERFORMANCES OF DESIGN PATTERNS

Web and Mobile Application Design Pattern Overall Comparison

	RWD	AWD	M.dot
Total Score of Information Service Quality (42%)	**17.67** ③	**20.5** ②	**16.33** ④
Platform Visibility	5.67	5.5	5
Search Function	3.33	3.5	2.67
Interactivity Function	2	2.5	2.67
Multimedia Application	5.33	2.5	3.33
Compatility	0	5.5	1.33
Page Load Speed	1.33	1	1.33
Total score of System Usability Quality (28%)	**19.33** ③	**20.25** ②	**17.33** ④
Information Search Usability	4.67	5.5	4
Intuitively Operability	5	5.25	4.67
Layouts	5	4.75	4.33
Overall satisfaction	4.67	4.75	4.33
Total Score of System Design Quality (28%)	**20.67** ②	**23.5** ①	**19.33** ③
Information Connectivity	7	7	6
Interface Design and Layout	5.33	5.5	3
Navigation Architecture Design	3.67	4	5.67
Consistency	4.67	7	4.67
Total score of whole quality facets	**57.67** ③	**64.25** ①	**53** ④

Although AWD stands for the best design pattern here, as a matter of fact, there are three indicators of APP, platform visibility, information connectivity, interface design, and layout that cannot be evaluated by tools. If we exclude this limitation, then APP would be the best design pattern in this work.

B. Data Analysis Toward Sample Platform Assessment

Table VIII shows the performance of sample platforms using different design patterns. With the emergence of mobile devices, it is difficult to convert the design pattern of the traditional web; therefore, the traditional web is excluded from this work.

In this paper, we begin with Facebook and Dcard as two social media platforms here.

The order towards Facebook is APP(71)→M.dot(64); Dcard: AWD(64.5)→APP(61). The overall performance of social media platforms is APP(66) → AWD(64.5) → M.dot(64). Social media platforms have the best performance under APP design patterns.

Then, udn.com and The Storm Media as news media platforms, the order towards udn.com is ranked as follows: APP (54) → RWD (51) → M.dot (44), and The Storm Media: RWD (61) → APP (47).

In total, The overall performance of news media platforms is RWD(57.6)→APP(50.5)→M.dot(44). News media platform has the best performance under the RWD design pattern.

Finally, for e-commerce platforms, Momo and Shopee, the ranking towards momo is APP(66) → M.dot(51), and the ranking towards Shopee is APP(66) → AWD(64). The overall performance of the e-commerce platform is APP(66) → AWD(64) → M.dot(51). To sum up, in this study, we conclude that E-commerce platforms have the best performance under the APP design pattern.

TABLE VIII. THE PERFORMANCE OF SAMPLE PLATFORMS USING DIFFERENT DESIGN PATTERNS

Platform name	Desktop Browser	Mobile Browser	Mobile Application Browser
Facebook	85（Traditional）	64（M.dot）	71
Dcard	67（AWD）	62（AWD）	61
udn.com	51（RWD）	44（M.dot）	54
The Storm Media	61（RWD）	61（RWD）	47
momo	47（Traditional）	51（M.dot）	66
Shopee	68（AWD）	60（AWD）	66

VI. CONCLUSION

In order to provide suggestions for platform owners and developers to adopt a suitable design pattern to improve user experience. In this paper, based on four web and mobile application design patterns, Response Web Design (RWD), Adaptive Web Design (AWD), Separate URLs (M.dot), and mobile application software (APP), we sum up 14 quality indicators for assessing web and mobile application design patterns. At the same time, we also integrate three types of platforms (social media, news media, and e-commerce), including six sample platforms, to conduct quality assessments. Finally, we give out a complete and systematic analysis.

According to the analysis results of the individual design patterns, APP design patterns are recommended for the platforms whose quality requirements are functional applications, loading response speed, and user experience. AWD design patterns are recommended for the platforms whose quality requirements are information connectivity and

interface design and layout. RWD design patterns are recommended for the platforms whose quality requirements are platform visibility and information connectivity. If an existing platform has already developed traditional web design and it's difficult to adjust greatly, the alternative of increasing the development of M.dot.is recommended.

The purpose of this research is to provide a clearer understanding for platform owners, designers, and developers on how to select the appropriate design pattern of the platform based on the desired quality facets to effectively improve user experience.

For further research, in order to better provide advice for platform owners more completely. We'll additionally consider two variables which are time and cost in the evaluation of the four design patterns. From a project management perspective, these two factors are crucial to enhance the robustness of the analysis. The possible method is to take both time and cost into account according to the requirement of development, maintenance, and release for each design pattern.

It is also suggested to include the development of a quality assessment tool that incorporates all the indicators discussed in this paper, in order to provide platform owners, designers, and developers with a more comprehensive and objective reference for decision-making regarding the quality of web and mobile application software.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Yi-Qi Chen and Sun-Jen Huang conducted the research; Yi-Qi Chen and Sun-Jen Huang analyzed the data; I-Ting Hsiao and Yu-Hsiang Chien wrote the paper; all authors had approved the final version.

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