A RIGOROUS APPROACH TO PRIORITIZING CHALLENGES OF WEB-BASED APPLICATION SYSTEMS

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ABSTRACT

Web innovations are unique advancements of software engineering. They are equipped with new apparatuses, novel systems, and revolutionary plans, ready to be used by web application developers and their users. According to their importance for web application improvement, there is a need to locate a fitting approach to adapt to these challenges. Therefore, the core objective of this study is to rank the challenges that were encountered by the developers and users of web-based applications. This study contributes to knowledge by proposing a hierarchical framework for identifying and categorizing the challenges appropriately. An exhaustive list of sixty-nine challenges was formulated, based on extensive literature review. Quantitative in nature, this study uses the survey questionnaire to collect data from 87 experts in the web innovation domain. Various statistical models like the Cronbach's Alpha, Principal Component Analysis, Stepwise, and Logistics Regression were employed to analyze the data. The stepwise regression was deployed to formulate the hierarchy of the extracted challenges. The outcome of the proposed framework would lead to a more efficient development and utilization of web applications. The limitations and future directions of this study were also discussed.

Keywords: web challenges, web systems, hierarchy of web challenges, crucial web challenges, empirical study

1.0 INTRODUCTION

Recent years have witnessed an upsurge in technological development; this is followed by the pervasive use of the web, web technologies and web applications. Current literature is replete with accounts casting light on various types and sizes of organizations integrating web technologies into their operations [1-3]. The wide interest in the subject is attributed to the fact that organizations are becoming aware of the possible implications of the Internet on their work, hence its adoption into organizational operations. The huge potential of the web applications has incurred organizations to spend huge sums of money on the technology which can enable organizations to easily reach out to customers, provide them with an exodus of information, products, or services, as well as opportunities for interactive business transactions. Web-based applications are being adopted for different interests, such as academia, politics, business, games, designs, and so on. The digital world today has caused traditional business transactions which merely uses Information Technology (IT) to shift to web applications for a more competitive edge and values [3-5]. These web-based applications have serious impacts on the business activities, and the behaviors of individuals. First, they improve the effectiveness of users' work such as more access to information, fast deliveries, speedy exchanges, and so on. They also change people's lifestyles - online shopping, online food takeaway, online order for a taxi, online registration for education, online submission for assignments, even online divorce and online wills [6]. For all of these online activities to be popular, the maintenance of an effective website is mandatory, regardless of industry. An efficient website makes transactions easy, fast, and instant. An efficient website fortifies the relationship between business operators and their customers, thereby broadening the market space. Organizations investing in web technologies and applications look forward to realizing these benefits from their investments. However, this would be impossible without knowing the type of challenges being faced by investors. Thus, an appropriate tool that can detect and address these challenges is imperative. Many companies had indeed adapted the new information and communication technology into their firms for improving the performance of their activities. These are used not just to support remnants of their traditional activities, but also to resolve some of the emerging challenges arising from their use of web applications, largely from the Internet [7].

The wide dispersion of web-based applications had not only created a significant demand for these applications, but it also brought with it an extensive range of complexities and challenges. Every moment these challenges are not addressed, the number of issues also increases. Thus, these challenges must be quickly identified and addressed.

An in-depth study of the literature reveals that the heterogeneity of components utilized by web applications leads to complexities. Some of these issues are linked to the designs. It appears that the methodology by which these web-based applications were developed, deployed, and managed have raised serious challenges [8]. Some of these issues were linked to security, reliability, maintenance and navigation issues, besides others. The latest report of internet security threats mentioned that 229,000 attacks were launched against websites every day, with more than 76% of websites becoming victims and having unrepaired susceptibilities [9]. Therefore, this study focuses on the prioritization of identified challenges so that each of the challenges may be addressed concerning its importance and priority.

These prioritized challenges are categorized into various dimensions by mapping the challenges on integrating the Sustainable Quality Assessment Model for Information Delivery in E-learning Systems (SQAMELS), and Information System (IS) model. To prioritize these challenges, a hierarchical framework was also formulated. This is necessary because the delivery and maintenance of high-quality web applications are obligatory for enhancing customer satisfaction and loyalty [10]. Therefore, based on the above discussion, the following Research Objectives (RO) have been formulated (as illustrated in Fig. 1);

RO1: To identify, collect and analyze the existing scattered challenges or issues of web-based application systems.
RO2: To formulate a comprehensive list of challenges of web-based application systems.
RO3: To extract the crucial challenges of web-based applications.
RO4: To articulate the general categorization of identified challenges/issues.
RO5: To rank the identified challenges concerning their crucial nature.
RO6: To formulate the hierarchical framework according to the severity of challenges.

This paper is organized as follows. Section 2 presents the background of this study, Section 3 states the research methodology deployed, Section 4 delineates the analysis of data, Section 5 describes the results of the data, Section 6 looks at the categorization of challenges of web-based applications, Section 7 discloses the hierarchical framework for meeting the challenges of web-based applications, and Section 8 concludes the paper.

2.0 BACKGROUND

The concept of web was proposed in 1989 by Tim Berners-Lee at the European Laboratory, CERN, in Geneva for Particle Physics. It was described as a way of structuring documents which can be linked to each other, whenever and wherever, making the web of documents a domain with convenient browsing [11]. In 1990, Tim Berners-Lee built his first web browser, calling it the worldwide web (WWW) [12]. It was introduced to make information accessible, from any source possible, in a simple and consistent manner [13]. The WWW was used as a delivery platform for various types of web applications – from online personal static web pages to complex, dynamic Customer-Relationship Management (CRM) applications [14]. Over the years, the growth of the web community has increased drastically, with the number of users increasing to billions. [15]. The web-based applications are becoming bigger, more intense, interactive and essential for survival in today's age of technology.

The current situation of the use of web applications is that it is being deployed by all the big, private and public organizations over available networks such as the Internet and Intranet. Catering to the demands of customers who now have expectations of the quality of the web applications, organizations now need to be more competitive [16]. The study conducted by the National Research Council in1999 stated that the current base of technology and science serving the world is inadequate in taking control of critical software infrastructure of the building systems [17]. This was further highlighted by the President's commission in the PITAC report of 1998. Some of the inadequacies were traced to the high risk of novel zones of web-based applications software. Innumerable cutting-edge technologies are being deployed for web-based software, but information about the quality attributes like reliability of web applications is yet to be known [16]. The security and credibility of information is another contentious widespread issue. This also indicates why there is a need to find an alternative that can address the various challenges that can be duly tackled for the successful development and deployment of web-based applications.

As mentioned before, web-based applications are constantly being researched but the challenges being encountered by web-based applications have not been duly addressed in general. Since quality is crucial and essential for measuring the survival of the software system, a great amount of work has been done about the quality of web-based applications

[18]. In this study, an effort was done to define the quality of web-based applications in the context of the internet used by business school websites [19]. Examples can be traced to George Rose who focused on the quality of academic and commercial web-based applications [20] and [18] emphasized the diverse characteristics in the quality of web-based systems. These characteristics include functionality, reliability, usability, efficiency, portability and maintainability. Information quality, reliability, portability, maintainability, security and usability are coined as quality model characteristics [21].

Another research considered only two aspects - design and content of the web-based applications [22] while another study focused on the theoretical description of the technological obstructions of web sites, done to aid the development of web applications [23]. Whereas, seven mistakes of website designs were detected [24], to enhance the design of the web-based applications. In a study [25], researchers have also recommended 39 guidelines which were noted to be relevant to web site graphics, text, links, page size and length, and multimedia. Existing scientific research [19, 25, 26] had discussed some aspects of the quality of web-based contents which include: ease of use, customization, security, functionality, speed, navigation, content, graphics, access to web, user-friendliness, unique features and usefulness. In relation, attractiveness, speed of loading, currency, accuracy, navigation usability, and interactivity of web applications were also noted as key characteristics of websites [27]. Other issues such as navigation, speed and access to web-based applications have also been portrayed as an obstacle to the success of web-based applications [28]. However, the studies of researchers were confined to the navigation and organization perspectives. In a research examining Information content, the ease of contents, usability, download speed, customization, and security, was named as the characteristics of the web sites. Here, 40 websites were evaluated based on these characteristics [29]. Various cross-browser issues like effort, application functionality, page layout and time that are merely identifiable and lack visible effects were addressed to the pave way for success of web-based applications [30].

Security is a critical issue for any web application. Thus, it is necessary to understand what vulnerabilities are involved in the successful development of web applications [31]. A recent study noted that the lack of resources, power failure, bandwidth, and literacy rates, were some of the challenges involved by the use of web applications [32]. Further research tried another solution for the privacy issues of web-based applications as a focussed outcome. Most of the studies focused on small sets of challenges or limited specific challenges, as in the case of [23], that addressed only six factors, whereas [26] mentioned eight factors. Even an extensive study was conducted by [33], but it still lacked mention of numerous critical challenges such as clarity, web security, accuracy and availability. Cross browning, Availability, Reliability, Reusability and Navigation are specific challenges that need to be addressed specifically. Based on the above discussion, it can be safely concluded that current literature discussed web-based issues from diverse perspectives, but rarely listing all the challenges of all the mentioned dimensions together. Findings of the literature review also revealed that the most prevalent and crucial of the challenges of the websites need to be addressed in general. Furthermore, the categorization of the challenges of web-based application remains unexplored that has been attained in this study. Hence, to achieve the objectives of the study (as discussed above), a set of research questions (RQ) has also been formulated;

RQ1: What are the challenges faced by the web-based applications?
RQ2: Which challenges of web-based applications are crucial?
RQ3: What are the categories of these challenges?
RQ4: What could be the ranking of challenges of web-based applications according to their severity for the development of a hierarchical framework?

3.0 RESEARCH METHOD

The selection of an appropriate research method is crucial for the attainment of research objectives. A comprehensive quantitative research methodology was adopted to achieve the research objectives of this study as illustrated in Fig. 1. The quantitative model of research can be defined as an approach that stresses quantification from data gathering to analysis [34]. It reflects that quantitative research refers to amount to something. Various questions starting with how much, to what extent and how many are answered by adopting this methodology [35]. Measurements and the variables of the social world are specifically focused on quantitative methods [36]. Before the study, an in-depth literature search was conducted to trace the challenges. As a result, an exhaustive list of 69 challenges was formulated. Survey instrument have been formulated to collect data form the targeted sample (as discussed in Section 3.1).

It has been urged by Payne and Payne [37] that, “Regularities are deduced out in the human lives by employing quantitative methods. The social world around humans is portioned into components and these components are named as variables, which are represented by using numerical values such as rate or frequencies. The association of these variables could be explored by practicing statistical techniques and could also be accessed by systematic measurements and research induced stimulus”. Apart from sampling, data analyses in the quantitative mode of

research are efficient due to the utilization of statistical software like SPSS [38]. Therefore, various statistical techniques like Cronbach's Alpha, Principal Component Analysis (PCA), logistic regression odds ratio, the goodness of fit, and Chi-square were employed utilizing different statistical software (like SPSS, STATA and etc.) to analyze the data collected from the survey. The survey instrument was tested for its reliability and internal consistency with Cronbach's alpha whereas Cohen's Kappa was applied to inspecting the inter rater's reliability on the data obtained from the survey. Logistic regression following stepwise regression was used to identify the potential contributors. All these methods were employed to formulate the hierarchy of the extracted challenges.

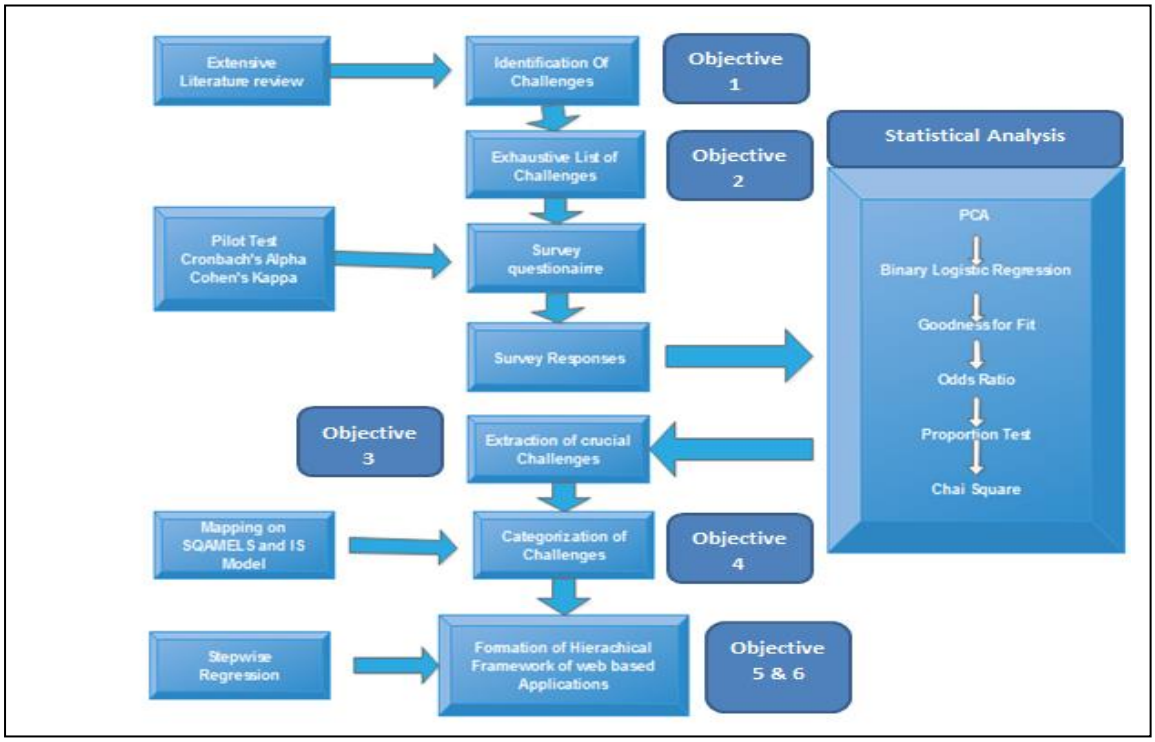

Fig. 1: Research methodology

A total of 6 research objectives (as discussed in Section I) are required to be achieved by this research study. Accomplishment of RO1 and RO2 were attained by formulating an exhaustive list comprising of 69 challenges of web-based applications following extensive literature review. Crucial challenges have been extracted from the list deploying Principle Component Analysis (PCA) which led this study to the acquirement of RO3. Extracted challenges were then categorized according to their nature, this contributes to the achievement of RO4. RO5 and RO6 lead to the arrangement of challenges according to their severity towards web applications and the formulation of the hierarchical framework respectively.

3.1 Research Instrument and Sample population

A questionnaire was developed. It was pilot tested with experts of the domain before it was administered on the respondents selected for the current study. The rationale behind the pilot test was to ensure the reliability and validity of the survey items developed. It was also meant to remove the biasness of the respondents in identifying the severity of the web-based application challenges. Following adjustments made to the survey questionnaire based on the feedback received, the instrument was distributed among IT experts academicians from higher education institutions, software developers and software administrators from the software industry. The experts were selected based on their experience (as illustrated in Table 2). The inclusion criteria for respondent selection was that they must have an average of five years of working experience in their respective domains. A total of 120 survey questionnaires were distributed to the respondents. In total, only 85 sets of responses were received, at the response rate of 70%.

The open-ended survey was considered less biased as it does not limit the consent of the respondents. Challenges detected upon the literature review were added into the questionnaire based on the results obtained from the pilot test. The major sources of data gathering are shown in Fig. 2.

Fig. 2: Sources of Data gathering

The questionnaire requests respondents to rate each challenge by using the 5-point Likert Scale which ranged from not crucial (1) to most crucial (5) according to their severity level. The scale values which were assigned to the responses are depicted in Table 1.

Table 1: Likert Scale

Level of agreement	Scale value
Most crucial(MC)	5
Crucial(C)	4
Normal(N)	3
Least crucial(LC)	2
Not crucial(NC)	1

The 85 respondents who participated in this study were also gathered for their demographic information. These are tabulated in Table 2 below.

Table 2**:** Demographic profile of respondents

Demographics	Frequency	Percentage
Gender:		
Male	44	52.38
Female	40	47.61
Age		
21-30	10	11.90
31-40	24	28.57
41-50	35	41.66
51-60	15	17.86
Qualifications:		
MS(CS)	43	51.19
Master	35	41.66
Doctorate	6	7.14
Designation:		
Web Developer	20	23.80
Software Engineer	30	35.71
Research Scholars	34	40.47

3.2 Data Gathering

The state-of-the-art challenges of web-based applications were compiled based on a detailed review of 70 journal articles that were downloaded from various well-renowned databases like Springer, Web of Science, Emerald, Elsevier and etc. A total of 69 exhaustive challenges were detected as tabulated in Table 3.

Table 3: Challenges of web based applications

Security [20, 22, 31, 33, 39-45]	Ease of navigation [20, 22, 33, 39-44]	Broadcast services [20, 22, 33, 39-44]	Availability [20, 22, 33, 39-44]
Limited use of special plug-ins [20, 22, 33, 39-44]	Adaptability [20, 22, 33, 39-44, 46]	Valid links [20, 22, 33, 39-44]	Reliability [20, 22, 33, 39-44]
Browser sniffing [20, 22, 33, 39-43] [44]	Personalization [20, 22, 33, 39-44]	Speedy page loading [20, 22, 33, 39-44]	Interactivity [20, 22, 33, 39-44]
Accessibility [20, 22, 33, 39-44]	Multilanguage support [20, 22, 33, 39-44]	Bookmark facility [20, 22, 33, 39-44]	Usefulness of content [19, 22, 25, 47-50]
Clarity of content [19, 22, 25, 47-50]	Completeness of content [19, 22, 25, 47, 50]	Uniqueness of content [19, 22, 25, 47, 50]	Broadness of content [19, 22, 25, 47, 50]
Originality of content [19, 22, 25, 47, 50]	Currency of content [19, 22, 25, 47, 50]	Conciseness of content [19, 22, 25, 47, 50]	Accuracy of content [19, 22, 25, 47, 49, 50]
Diversity of content [19, 22, 25, 47-50]	Attractiveness [19, 26, 50-54]	Distinctive hot buttons [19, 26, 50-52, 54]	Changing look [19, 26, 50-54]
Proper use of fonts [19, 26, 50-54]	Proper use of colors [19, 26, 50-54]	Proper use of multimedia [19, 26, 50-54]	Style consistency [19, 26, 50-54]
Good labeling [19, 26, 50-54]	Proper choice of page length [19, 26, 50-54]	Proper use of language/style [19, 26, 50-54]	Color consistency [19, 26, 50-54]
Proper use of graphics [19, 26, 50-54]	Organization of content [19, 26, 50-54]	Graphics-text balance [19, 26, 50-54]	Interoperability [7]
Performance [42, 55]	Scalability [16, 42]	Browser compatibility [30, 43]	Maintainability[56]
Reusability [57]	Supportability [58]	Usability [48, 59]	Testability [55, 60]
Management [26]	User Interface Design [61]	Control Flow [62]	Integrating Different Technologies [62]
Network Load Management [63]	Cryptic Error Message [64]	Data Integrity [65]	Socio culture [58]
Bandwidth [32, 66, 67]	Power Failure [32, 68-70]	Literacy rate [32]	Cost of mobile internet [32]
Lack of resources [32, 68]	Accuracy [55, 60]	Download speed [20, 22, 33, 39-44, 55]	Coexistence [26]
Profitability [71]	Efficiency [42, 55]	Database designs [72]	Installation ability [20, 22, 33, 39-44]
Portability [73]			

4.0 DATA ANALYSIS

The analysis of data was arranged according to the research questions formulated. For answering "RQ1**:** What are the challenges faced by the web-based applications?", an exhaustive list of 69 challenges were formulated. The challenges were gathered after reviewing the research articles and case studies published by various well-known journals and conferences. To answer "RQ2: Which of the challenges of web-based applications is crucial?", various research tools were deployed to analyze the data gathered from the survey. These include Cronbach's Alpha, PCA, Cohen's Kappa, proportion test and descriptive analysis. The answer to "RQ3: What are the categories of these challenges?" was provided by categorizing the challenges of web-based applications based on the SQAMELS and D&M IS model. Whereas, to answer the "RQ4: What could be the ranking of challenges of web-based application according to their severity for development of hierarchical framework?", deploying logistic regression following stepwise regression assisted this study to develop the hierarchical framework of challenges of web-based application systems.

4.1 Principal Component Analysis (PCA)

The PCA is undoubtedly the most famous multivariate statistical technique used, virtually in all scientific disciplines. The PCA analyzes tabular data that represent observations from several dependent variables. The main purpose of the PCA is to extract important data, and to express this data as a set of new orthogonal variables [74]. The PCA reduces large numbers of challenges so that items with very small proportions like ≤0.03, can be neglected [74]. Using minimal efforts, the PCA can provide a roadmap for reducing complex data sets into lower dimensions to uncover any hidden simplified data that underlies it [75].

4.2 Cronbach's Alpha

Alpha was first designed by Lee Cronbach in 1951 to gauge the internal consistency of a scale or test [76]. The internal consistency explains the extent to which all items in the test measure the same construct or concept. The number of items in the test, the inter-relatedness of items, and the dimensionality has an impact on the value of the alpha [77]. The acceptable value of the alpha should range from 0.70 to 0.95 [78-80]. A low-value alpha could be due to a low number of questions, or poor inter-relatedness between items/heterogeneous constructs [81]. In this study, the value of our result was 0.87, which shows the reliability of the data.

4.3 Cohen's Kappa

The Kappa statistics was first suggested by Cohen (1960). It was projected to evaluate the agreement between two or more equally skilled observers. The Kappa coefficient is used to measure the categorical agreement between two raters [82], hence the raters can be added. The strength of the agreement value of the kappa statistics should be ≤ 1.0. In the current study, the strength of the rater's agreement was 0.74, which is substantial, according to [83]. Table 4 further illustrates.

Table 4: Agreement Levels

Agreements	Values
Disagreement	≤0
Slight Agreement	0.01–0.20
Fair Agreement	0.21–0.40
Moderate Agreement	0.41– 0.60
Strongly Agreement	0.61–0.80

4.4 Binary Logistics Regression

The binary logistics regression is a special type of regression analysis. It outstretches the technique of multiple regression analysis to work for situations where the output variable is categorical [84]. In this process, the response value follows from the exponential distribution, rather than from normal distribution. It facilitates checking the association between the response of one or more variables. The independent variable can be continuous, categorical or a mix of both. By further extending the logistics, the goodness of fit can be implied through Pearson's correlation, deviance, or the Hosmer Lemeshow tests.

4.5 Stepwise Regression

Stepwise Regression analysis is an automated procedure; it starts with the intercept and then keeps on adding the variables that are of the best fit. These variables are inserted into the model. Then they are inspected to check whether the variables need to be deleted or not. The same process continues and the variables are added one after the other, until the model is developed [85]. Stepwise regression analysis is frequently employed in educational research for selecting useful variables, and for evaluating the order of importance of these variables [86].

5.0 RESULTS

5.1 Internal Consistency of Instrument

The Cronbach's alpha test was applied to gauge the validity of the survey instrument. The value of Cronbach's alpha coefficient should be greater than 0.7 for it to be reliable. In the current study, the value of the Cronbach's alpha coefficient obtained was 0.79, which depicts the survey instrument to be of good reliability.

5.2 Extraction of Crucial Challenges

The Principal Component Analysis (PCA) was implied to extract the crucial challenges from an exhaustive list of identified challenges to devise a framework for the web-based application challenges. The main motive of using the PCA was to reduce the exhaustive list of challenges into a smaller dataset. Consequently, the framework was able to express these as a set of new variables [74]. The reduction of the challenges was based on the responses of the respondents collected from the survey questionnaire. The challenges extracted by the PCA are depicted in a scree plot, as addressed in Fig. 3.

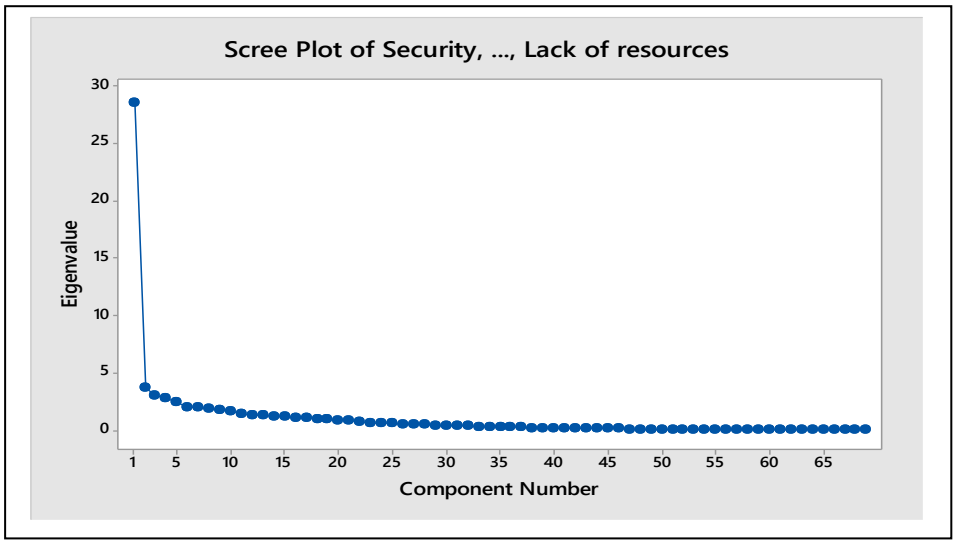

Fig. 3: Scree plot of Challenges

The scree plot helps to display the eigenvalues associated with the challenges in a descending order. The eigenvalues are listed on the y-axis whereas the challenges are portrayed on the x-axis. The scree plot depicts the relationship between a challenge and its eigenvalue. Fig. 3 depicts 69 challenges of the web-based applications. The scree plot showed that 15 of these challenges indicated maximum variability. Table 5 further demonstrates.

Table 5: Extracted crucial challenges

	Challenges	Percentage	Cumulative %
C1	Availability	21.9615	21.9615
C2	Accuracy	15.3886	37.3501
C3	Accessibility	13.1706	50.5207
C4	Reliability	12.0931	62.6137
C5	Usability	8.16	70.7737
C6	Interactivity	7.1548	77.9286
C7	Performance	7.0346	84.9631
C8	Efficiency	6.0311	90.9942
C9	Scalability	5.3	96.2942
C10	Security	0.998	97.2922
C11	Adaptability	0.909	98.2012
C12	Clarity of content	0.6166	98.8177
C13	Data Integrity	0.311	99.1287
C14	Testability	0.283	99.4117
C15	Reusability	0.184	99.5957
	Rest All	0.4043	100

5.3 Significance of the Challenges

The binary logistics regression was applied to calculate the significance of the challenges. The values obtained from this test are also depicted in Table 6.

Table 6: Significance of extracted challenges

Sr. No.	Predictor	Coefficient	SE Coefficient	P	Odds Ratio
	Constant	6.2	10.5	0	
1	Availability	-0.393	0.305	0.0019	0.6749
2	Accuracy	0.131	0.324	0.00684	1.1403
3	Accessibility	0.461	0.299	0.00108	1.5856
4	Reliability	-0.127	0.315	0.000684	0.8803
5	Usability	0.269	0.321	0.00398	1.3092
6	Interactivity	-0.023	0.294	0.00936	0.9768
7	Performance	0.112	0.283	0.00692	1.1185
8	Efficiency	-0.078	0.33	0.00815	0.9254
9	Scalability	-0.246	0.303	0.0412	0.7819
10	Security	0.134	0.277	0.03628	1.1434
11	Adaptability	-0.304	0.322	0.0345	0.7381
12	Clarity of content	-0.314	0.358	0.0377	0.7307
13	Data Integrity	-0.341	0.277	0.0212	0.7112
14	Testability	0.248	0.293	0.0396	1.2817
15	Reusability	0.286	0.834	0.00735	1.3312

If the p-value of the challenge is less than 0.05 then that challenge is considered as significant. Significant means that challenge is crucial for the effective development and deployment of web-based systems. The p values of all the challenges given in Table 6 are less than 0.05 which depicts the criticality of these challenges. So the results from logistic regression analysis ascertain to consider only the challenges that are listed in Table 5.

Another statistical method that is widely implied to gauge the cruciality of the challenges is the odds ratio. The odds ratio is used to inspect how strongly the absence or presence of a specific property A impacts the presence of another property B in a population. If the odds ratio of a challenge is greater than 1 this is considered as effective. As much as the value is greater than 1, stronger is the association. As per Table 6, accessibility is the challenge with the highest

odds ratio value of 1.58. Usability and reusability being at second with the odds ratio value of 1.3. The results from the odds ratio appreciate the decision of selecting 15 challenges and ignoring others.

5.4 Impact of the Challenges on the Effective Development and Deployment of the Web

This study also aims to understand what impact these challenges may have on the web, hence a process had to be designed to test the impact.

Applications

The following hypothesis was devised to check the impact of the challenges on the efficient development and deployment of web-based applications.

1. H_o : if $B_1 = 0$ challenge has no effect
   If $B_1 \neq 0$ challenge has effect
2. Level of significance $\alpha = 0.05$
3. Test statistics: $t = \frac{\hat{B}-B}{SE(B^{\wedge S})}$
4. Decision

If the p-value was less than 0.05, then the challenge has an impact on the effective development and deployment of the web-based applications. This test validates the decision of considering only 15 challenges for this study while the others were omitted due to their negligible impact.

5.5 Goodness of Fit for the Logistic Regression Model

The results obtained from the logistic regression model were considered reliable if the model achieves a goodness of fit test. The following conditions were formulated to ensure that the logistic regression model was good to fit for the data collected from the survey. The aim was to check that the web-based applications were effective for the proposition of the hierarchical framework.

1. H_o: Model is good fit
   H_1: Model is not good fit
2. Level of significance $\alpha = 0.05$
3. Test statistics:
   a. Pearson
   b. Deviance
   c. Hosmer-Lemeshow
4. Decision

Based on the above, the p-value should be greater than 0.05 for the model to be considered fit for the said tests. The results of the goodness of fit test are given in Table 7.

Table 7: Goodness for fit

Test	DF	Chi-Square	P-Value
Deviance	84	82.33	0.531
Pearson	84	110.53	0.628
Hosmer-Lemeshow	8	3.06	0.93

As the p-value is greater than 0.05, it depicts that the results obtained from logistic regression are reliable and further analysis of the obtained results could be done. Table 7 strengthens the results illustrated in Table 6.

5.6 Comparison of Proportions

The proportion test was applied to inspect the homogeneity of the fractions. The Chi-square was used to measure the proportion of samples, and to check the relationship between two variables. The p-value less than 0.05 depicts that the relationship between the variables is significant. The results of the Chi-square are tabulated in Table 8. The p values indicated that the relationship between the variables was significant.

Table 8: Comparison of proportions

Source	DF	Adj Dev	Adj Mean	Chi-Square	P-Value
Regression	15	11.9443	0.79629	11.94	0.683
C1	1	1.7198	1.71979	1.72	0.19
C2	1	0.1657	0.16566	0.17	0.684
C3	1	2.5822	2.5822	2.58	0.108
C4	1	0.1661	0.16613	0.17	0.684
C5	1	0.7132	0.7132	0.71	0.398
C6	1	0.0064	0.00639	0.01	0.936
C7	1	0.1572	0.15725	0.16	0.692
C8	1	0.0549	0.05494	0.05	0.815
C9	1	0.673	0.67305	0.67	0.412
C10	1	0.2346	0.23459	0.23	0.628
C11	1	0.8918	0.89179	0.89	0.345
C12	1	0.7807	0.78067	0.78	0.377
C13	1	1.5604	1.5604	1.56	0.212
C14	1	0.7197	0.71967	0.72	0.396
C15	1	0.1149	0.11494	0.11	0.735
Error	84	82.3344	0.98017		
Total	99	94.2787			

Table 8 illustrates that challenges that are extracted play a significant role in the development of web applications. These extracted challenges are related to each other considerably. Furthermore, Table 8 also depicting the extracted challenges that play a significant role in the development of web applications. These extracted challenges are related to each other considerably.

6.0 Categorization of Challenges

As mentioned earlier, a total of 69 challenges were compiled based on the literature review. After the applications of the statistical tools, the number of factors was then reduced. Only 15 challenges were obtained after the PCA was conducted (as discussed in 5.2). Various statistical tools were engaged to verify the results of the PCA. The 15 challenges were then categorized by mapping them onto the categories that were devised in the D&M IS model and the SQAMELS [87, 88]. Four of these categories of challenges of web applications were proposed as i) System Quality, ii) Information Quality, iii) Service Quality, and iv) Use. The categorization of the challenges is depicted in Fig. 4.

a) System Quality

System quality was proposed based on the D&M IS Model. It is measured in terms of the ease of use, functionality, reliability, usability, adaptability, testability, portability and others [87].

b) Information Quality

Information quality corresponded to all the challenges of the web-based applications that are related to the quality of the web-based applications. In the D&M model, the challenge of information quality includes completeness, accuracy, timeliness, relevance and consistency.

c) Service Quality

Service quality was categorized as comprising accessibility, scalability, and security. In the SQAMELS, accessibility and security were listed together under service quality [88].

d) System Use

The last of the four challenges was system use. All the challenges that were related to the easy usage of the web-based applications and technologies were categorized under this component. It also corresponded to all the activities regarding the effective usage of web-based applications. According to the D&M IS model, system use includes the time of usage of the system, number of accesses, frequency of use, and others. In this model, efficiency, performance and interactivity were also collectively listed under the use category.

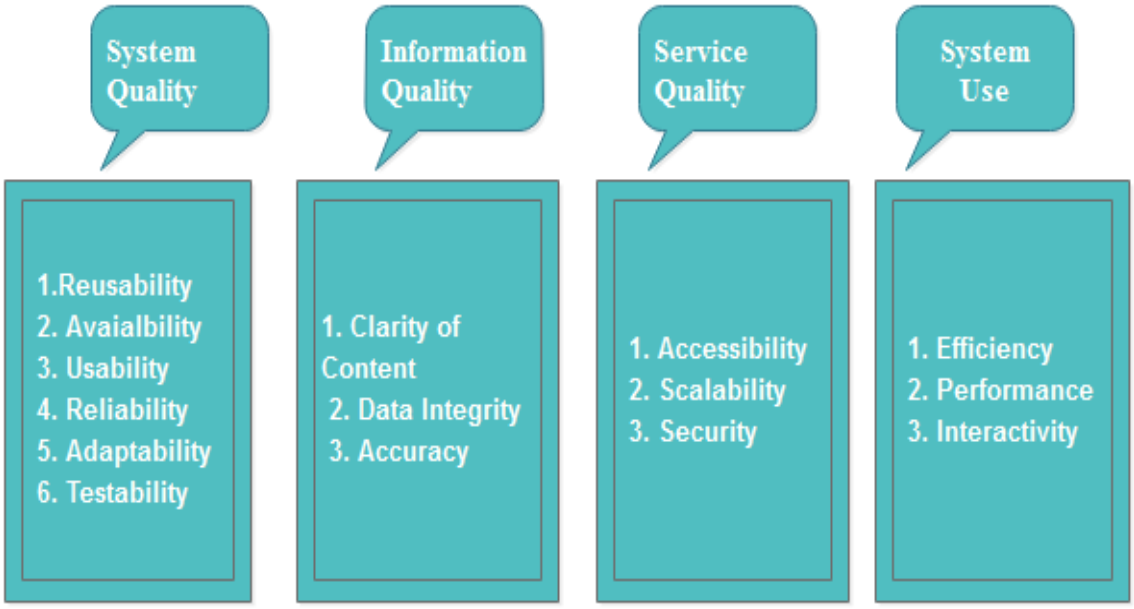

Fig. 4: Categorization of Challenges of Web-Based Applications

7.0 PROPOSITION OF HIERARCHICAL FRAMEWORK

Following all the processes that had been described so far, the challenges were finally arranged in a hierarchical form by applying the stepwise regression. The results obtained were consistent with the results of the PCA. The Stepwise Regression retrieved 18 challenges, but only 15 challenges were arranged in the hierarchical form as shown in Fig. 5. Availability, accuracy, accessibility, reliability were at the top positions whereas data integrity, stability and reusability occupied the ending positions of the hierarchy. Three of the 18 challenges detected, interactivity, and navigation and broadcast service, were ignored because their contributions were not significant.

The analysis generated from this study indicated that there were various challenges of the web-based applications which hindered the successful development and deployment of the applications. They are further elaborated.

7.1 Availability

Availability was the first in the hierarchy. The extent to which a system is available and operational for its users whenever it is required is termed as availability [89]. The requirement processes and data should be available to the users round the clock (24 hours a day, 7 days a week and 365 days a year) [18]. Availability measures whether web applications are available even in situations of server failure, and in providing good support even under high loads [46]. The availability of a system is one of the important factors for the success of web-based systems. The system is worthless if it is not available when it is required [88].

7.2 Accuracy

The extent to which information provided is authoritative, verifiable, objective, and correct is termed as accuracy [18]. Accuracy is also included in the ISO 9126 as an important quality of web-based applications.

7.3 Accessibility

The extent to which web application is quickly reachable and available for the internet users is referred to as accessibility. The availability of the application is mandatory, and applications should be available for use without difficulties. Accessibility is a major factor used in evaluating websites because without the availability of web-based systems, the browser will remain unable to return to it. The accessibility of the internet service, as well as the

accessibility of the web application from various browsers, is vital for the successful implementation of web-based applications.

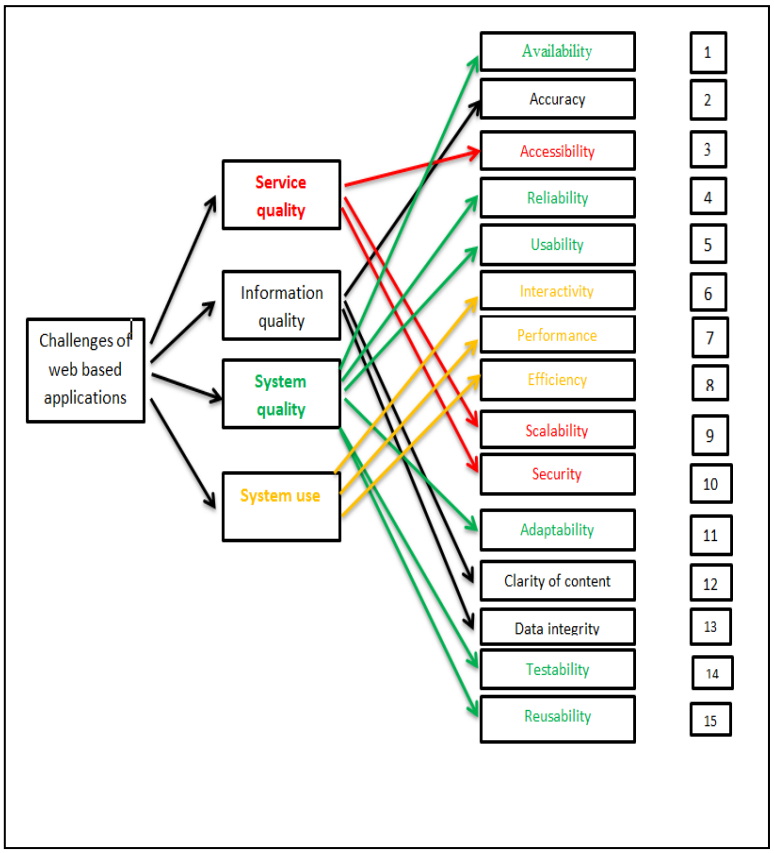

Fig. 5: Hierarchical Framework for Challenges of Web-Based Applications

7.4 Reliability

The capability of the web application to maintain its level of performance under specified conditions is termed as reliability. Reliability and performance can cripple a website even at the notice of a moment when the load on the website increases [42]. Little research has been done to explore the issue of the reliability of web-based systems. Reliability is the prime determinant of the quality and effectiveness of web-based systems [90]. The access speed of a website depends on the overall technical reliability of the web applications [29].

7.5 Usability

The extent to which a web application facilitates a user to fulfill his/her task is termed as usability. Usability is also termed as the degree to which a website can be easily used. Usability is the achievement of specified goals with effectiveness, efficiency and satisfaction, as gauged by the specified users [91]. The term usability is a comprehensive term that shadows the layout and attractiveness of the websites. It also relates to the use of the multimedia for enhancement of ease of use [29]. Usability is mandatory for the successful deployment of web-based systems. If the user remains unable to utilize the facilities provided by the website, the purpose of the website creation will be ruined.

7.6 Interactivity

In 1998, Liu and Hong introduced the Web-Based Applications (WBA) interactivity model which particularly focused on the importance of the interactivity factor in the WBA environment that can meet the satisfaction of users. The interactivity feature is crucial for enhancing users' satisfaction, the communication quality, as well as for engaging users, to make the web-based applications become usable and acceptable. Web-based applications incorporate a full range of navigational features to enhance interactivity [18]. The potential output of interactivity comprises performance quality, sense of satisfaction and fun, time-saving, and engagement. Despite the technical availability of

tools and theoretical underpinnings, interactivity is mostly not provided. A survey conducted on 408 websites revealed that only 35 percent of the websites provided interactivity [91].

7.7 Performance

The responsiveness of the system to the end-user under various load situations is termed as performance [42]. In short, response time, throughput, and cycle time for each workflow is performance. The performance of a web-based application is a cognitive issue since it varies according to the perception of the users [92]. Very little research has been done to explore performance. It is a dominant measure used to measure the success of an application, thus, more future studies should include performance as a component to consider in the framework of web-based applications.

7.8 Efficiency

Efficiency is defined as the ability of a website to assist the users to gather the required information easily and quickly [91]. In addition to this efficiency, the website is also able to reduce the irritation of users caused by the wastage of extra effort, and time in information seeking [91]. In other words, the relationship between the performance level of the software, and the amount of resources utilized under specified conditions, is termed as efficiency [90]. It is a major quality factor of the ISO 9126 along with usability and reliability. Personal relevance accounts for an increase in the efficiency of the websites as well as the value of the website [93] because the level of a website's efficiency is positively related to the value of the website [91].

7.9 Scalability

The degree to which the web-based application can be efficiently and easily expanded to cope with the requirements of users under specific conditions[18] is termed scalability. Scalable web applications can dramatically enhance the experience of users by increasing the interactivity level with the website [94]. As the load on a website increases, the communication and computations can be significantly delayed, this is also termed as scalability [42]. Scalability testing of web applications is mandatory for the successful deployment of the web applications [42].

7.10 Security

The degree to which information, data and processes are protected so that any unauthorized system or person cannot read or modify the protected content [18] is termed security. Security is vital for all applications, regardless of whether the application is offline or online. However, it becomes more vibrant when a document is shared by multiple people [90]. Systems security must be considered because any crack in the security may lead to a denial of service or a cessation in communication. Security is most critical for web applications that involve monetary transactions. Security is often used as an important predictor of user trust on websites [29]. Potential security issues may lead to the weakness of the website [95], hence security is necessary to be considered for the successful deployment of web applications.

7.11 Adaptability

The degree to which web-based applications could be adopted for a diverse specified environment is labeled as adaptability [18]. In other words, adaptability is the browser's ability to change the contents of the web applications, based on the browsing behavior, and state of the user's knowledge. Adaptability plays a significant role in modern web applications. Most of the currently existing frameworks lack user models that allow web applications to be designed with adaptive features [96]. Two different techniques of adaption have been discussed by [97]; they include adaptive presentation and adaptive navigation support [98]. An adaptive web application provides experts with more knowledge [98].

7.12 Clarity of Content

The easily understood contents of web applications is termed as the clarity of contents. The quality of web content is one of the major concerns assessed by web users when considering the quality factors of web-based applications. The clarity of content is the major requirement of e-commerce and e-health applications. Clear content will undeniably, enhance the understandability of the users. Web-based systems development methods should necessarily include the design and the development of content [1] such that the clarity of contents becomes a mandatory factor to ensure the efficient design of web-based applications [49].

7.13 Data integrity

Integrity refers to the requirement that data and processes within browsers remain protected from unauthorized modifications. The integrity of web-based applications is a legitimate concern because sometimes the communications that are applied over the internet inhibits data integrity and security risks [99].

7.14 Testability

The degree to which the modifications implemented in a web application can be verified is termed as testability [18]. The success criteria in the web-based application development is laid on testability, either by competent evaluators or by automatic tools [100]. This challenge is also experienced by web application developers in developing countries.

7.15 Reusability

Reusability reflects the presence of web-based application characteristics that allow for reapplications without any significant modification. Reusability is the ability of using an already existing piece of software in diverse contents [101]. It is a major quality factor from the developer's perspective. Abstract activity, modularity and the separation of contents are considered within the reusability component [18]. Adopting appropriate design patterns can lead to more reusable and consistent web applications [72, 101].

The 15 challenges of the web-applications have been discussed and explained above. The next section highlights the constraints faced in the current study.

8.0 RESEARCH LIMITATIONS

There are a few limitations imposed on this study;

a) There are various dimensions/categories of web application challenges like technical, cultural, economic and etc. that are equally important. However, this study only considered four dimensions - service quality, information quality, system quality, and system use.
b) This study is also limited by geographical zones. It only focussed on the web-applications used in Pakistan. Thus, the generalizability of the findings may be restricted although web-applications are used throughout the world.
c) Finally, this study only considered the challenges of web-based applications. Others like Android-based applications and desktop applications were excluded.

9.0 CONCLUSION

Indeed, web-based applications are rapidly increasing and its usage has also escalated in developing countries like Pakistan It is a country currently experiencing the slow pace of the internet based on the web applications. Due to this, it may also be experiencing many of the challenges offered by web-based applications. If these issues are not duly addressed, the country may become less competitive and lose out to the global market.

As it has been noted from the literature, web-based applications and its efficiency is very much hindered by various challenges. Web application developments are designed based on the merger of various techniques, thus various techniques tend to manifest different types of issues and challenges. This study proposed a hierarchical framework which could sequentially address the challenges of the web-based applications. This framework particularly focuses on the web-based application issues of Pakistan. The challenges highlighted by this study had been extracted from an in-depth literature review as well as a survey of 85 experts involved in this domain. All the challenges were then categorized from a huge dataset to a smaller dataset that was more practical. Following this, a total of 69 challenges were further classified into 15 challenges. It is expected that these itemized challenges which have been duly explained would be practical for the providers of the web-based applications. The identification of the crucial challenges of the web-based applications will enable the developers of web applications to consider these issues in their designs, and also for web providers when offering their users their respective services/products, particularly in the context of Pakistan. The systematic addressing of challenges that hampered the success of web-based applications as provided by the current study serves as a milestone for the developers, managers and users.

10.0 ACKNOWLEDGMENT

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