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A Proposed Web-Based Application Model for Improving Web Quality

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Abstract: Web-based applications are very popular nowadays. Where business owners rely on web applications to perform their works. As the success or failure of companies is related to these applications, and accordingly, web-based applications must be of high quality. For this purpose, this paper proposes to build a model to improve the quality of web applications. Previous studies have been based on the ISO 9126 model for building web models. ISO 9126 is a quality model divided into six main factors, each of which is composed of a group of other sub-factors. This study aims to enhance the six main characteristics with other sub-factors that contribute to quality improvement. This study seeks also to classify the factors according to stakeholders such as users, IT team and owners. Each model plays as an aid to the stakeholder in assessing the quality of its application. The model was applied to two projects, one academic and the other commercial. The percentages of results were very satisfactory. The form was filled out by 30 users and stakeholders to evaluate the proposed form. The results of the questionnaire used to suggest adding sub-factors to the six main factors showed an average of 91.1% and 89.34% for both applications used in terms of importance and satisfaction. It also showed the stakeholder importance and satisfaction rates of 89.25% and 88.33%, respectively. The idea of the survey is new and its results are satisfactory and promising to contribute to improving the quality of web-based applications as well as to identify stakeholders' priorities.

Keywords: Web based applications, quality assurance, ISO 9126, WBA

1 Introduction

Over the past two decades, companies have invested huge amounts of money in creating their own web applications to keep pace with the resulting development these days and keep pace with the times to keep pace with the advanced and distinguished business market [1].
In order to build these web applications and ensure their continuity, they had to consider the quality of the product (web applications) to keep up with today's business. In addition, due to the constant change in the business, they have had to take care of the quality of the sites as a top priority. Software quality is one of the areas of study and practice that describes the quality elements of a product and is divided into two categories, error management and quality standards. Bugs can be detected and removed through various techniques that contribute to improving code quality, such as bug detection and code smells in web applications [2].
As for quality standards, and the category on which our study is based, it includes external quality standards such as availability and others. When developing web applications, it is essential to create and use speech models and evaluation tools to facilitate and ensure the ongoing quality of those applications. However, assessing the quality of web applications is a new topic that is often overlooked. Several style guides, checklists, and design principles have appeared to assist developers in the development process. While these guidelines and techniques are useful in the web design process, they are not necessarily an evaluation method in and of themselves [3].
To apply these standards to web-based applications, the ISO 9126 model was built, a software quality assessment model that provides valuable results in software products that are reliable, effective, understandable, and accepted by stakeholders [4].
ISO standards define software quality, which is described as the use of internal and external software attributes or factors

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and their association sub factors or sub attributes. Many researchers have proposed models to contribute to the evaluation of web applications by building models and tools to help them [5,6,7,8,9,10]. However, the issue of internet applications is a new one, having been ignored in previous years. This study proposes to build an understanding model based on the ISO system as a reference point due to its popularity and selection as a quality model approved by the Software Authority. This model provides a classification of the major criteria of the ISO 9126 model by adding sub-criteria for the six major criteria, in addition to classifying the criteria according to stakeholders whether it is IT developers, owners or users of the site. This model was tested against a questionnaire showing aggregates taken to be evaluated by 30 stakeholders to measure their satisfaction with the model.
The rest of the paper is organized as follows: Section 2 discusses WBA and ISO 9216 Overview. Section 3 discusses the related work. Section 4 describes the proposed QWBA process while Section 5 shows the evaluation criteria and results. Finally, Section 6 discusses the conclusion and suggests some steps for future work.

2 WBA and ISO 9216 Overview

Because of the massive spread of digital transformation, the principle of applying technology has become familiar to everyone. Because of the great desire of stakeholders to apply technology to speed their work and keep pace with the times, everyone has turned to creating web-based applications to keep up with the technology and the rush of the world to run their business in the optimal way.
With the increase of web-based applications and the adoption of companies on them, the need for high quality is the focus of optimal attention for these applications. Several models have emerged that enable software developers and testers to confirm the quality of applications such as ISO 9126 and MCcall [11].
ISO 9126 aims to produce high quality applications to meet customer needs. The ISO 9126 Quality Model consists of four main parts. The first part is known as the quality model and includes six main factors by which the quality of systems can be assessed. The factors are portability, functionality, reliability, maintainability, efficiency, and ease of use [4], which are described in Table 1. They can be evaluated by measurement, questionnaire, interview, and observation.

Table 1: Six quality characteristics of ISO 9216

Factor	Description
Functionality	Describes a set of the main functions defined by the customer, how to implement them and the characteristics of each of them. This function meets the main requirements and needs of the client
Reliability	Represents the ability of the program to work in certain conditions with the same performance for a certain period of time
Usability	A set of characteristics that define the effort required for the usage and the evaluation
Efficiency	It Shows the correlation between the materials used under the current conditions and the level of program performance
Maintainability	Indicates the extent of changes and modifications required by the client and the efforts required to implement them
Portability	Represents the ability of the program to work in different environments

The second part of the ISO 9216 product quality model, classified by external dimensions, evaluates the performance of the computer used in the program execution process [12]. As for the third part of the ISO 9216 quality model, it is classified by applying inspection methods within the framework, according to internal standards [13]. The last one of the ISO 9216 Quality Model, Quality in Use [14], applies questionnaire, interview, observation/ethnography, and self-report methods.

As we explained in Table 1, the six main factors of ISO 9126 model, each of them follows a set of sub-factors, whose quality we were able to measure as shown in Figure 1.

Fig. 1: ISO 9126 model for software quality product

3 Related Work

Since the 1970s and over the past five decades, researchers have sought methodologies to measure software quality. They found that methodologies could be divided into small parts whose quality can be measured by evaluating those characteristics [15]. A large number of models were presented as follows:

McCall et al. [16] presented an initial quality model targeting the development process. This model sought to bridge the gap between developers and users by focusing on the software quality factor that reflects user opinions and priorities in addition to developer priorities. The model had three main dimensions: product review, product transition, and product operation. It also included three perspectives on the hierarchy of standards, factors, and measures where quality standards are described as attributes of one or more quality factors. Quality factors describe different types of systems. Quality standards are intended to define aspects of quality standards. The ISO 9126 model is based on the standards and criteria proposed by the McCall model to consist of the six standards described in the previous section.

Web-based applications have spread widely in society and have become indispensable in all areas, and for their importance, developers and users had to take into account their quality and focus on them. Since the spread of the Internet in the mid-1990s, many quality models have emerged that aim to evaluate the quality characteristics of WBA.

Lu and Hong [17] introduced an interactive quality model that aims to focus on stakeholder satisfaction through the interaction factor in a WBA environment. This is important in improving user satisfaction and thus making the application more acceptable and usable. This model focused on hopefully five key factors and me: fun, choice, interdependence, information gathering, and mutual communication.

Luisa et al [18] have proposed a WBA quality assessment model called 2QCV3Q that can similarly provide suggestions for improvements, provide guidance for WBA design, and categorize stakeholder requirements. The model focuses on achieving the goals of website owners and the needs of users.

Filippo et al [19] has provided a quality model that helps website professionals and developers while creating websites. This model contains features such as visibility, clarity, credibility, visitor engagement and differentiation. To include the level of customer and developer trust and the extent of credibility in addition to ease of use. This model seeks through the quality characteristics of WWW in addition to the individual characteristics to measure the extent of differentiation that highlights the extent of the superiority of the site or not.

Shirleen et al [20] presented a quality model for WBA content. Quality is one of the concerns that must be taken into consideration when talking about quality factors. They split the model into two quality perspectives: content quality and media quality. Each method in the mentioned content differs in its approach and application, but they share a number of characteristics.

Albuquerque et al [21] organized quality attributes into groups. Each group has a goal and each group is categorized into other subgroups. Its objective was to evaluate the quality of web-based e-commerce applications.

Marchetto et al [22] proposed a quality model consisting of a set of metrics that help the user measure the quality of WBA. The model was built into several groups that are used to analyse programs designed through a prioritization and

features approach. The model is used to analyse current programs related to specific functional issues or related to job integration.
Lilburn et al [23] built a WBA quality measurement model called QCF to measure usability from a user's point of view and maintainability for a developer. The model consists of components such as the quality measure, its objective, the sub-objective of each measure, and its quality.

4 Proposed QWBA Model

Web-based applications are among the fastest growing areas of the software world. Many people strive daily to learn different web technologies in multiple programming languages such as Java, C#, etc... Due to the need of the businesses, meet the needs of the client and increase their income.
Through this study, a quality conceptual framework based on ISO 9126 is proposed to help evaluate and improve the quality of web applications. Through classifying WBA into two parts, the first seeks to support ISO 9126 by employing and adding sub-factors to the six main factors to help improve the quality of WBA as shown in Figure 2. The second seeks to classify the stakeholders within WBA into the IT team, owners, and users as shown in Figure 3.

4.1 WBA as a software product side

Software quality is a constant source of concern for software developers, as it leads to permanent and embarrassing concern for software developers due to the software dangers and vulnerabilities caused by them [24]. The research perspective of WBA is as a product to the customer. It should focus on its quality through the application of ISO 9126. It contains six basic factors, and these factors include other sub-factors as shown in Fig. 1. This study seeks to add other sub-factors related to web quality standards for each major factor as shown in Fig. 2 to contribute to improving the quality of web applications globally.

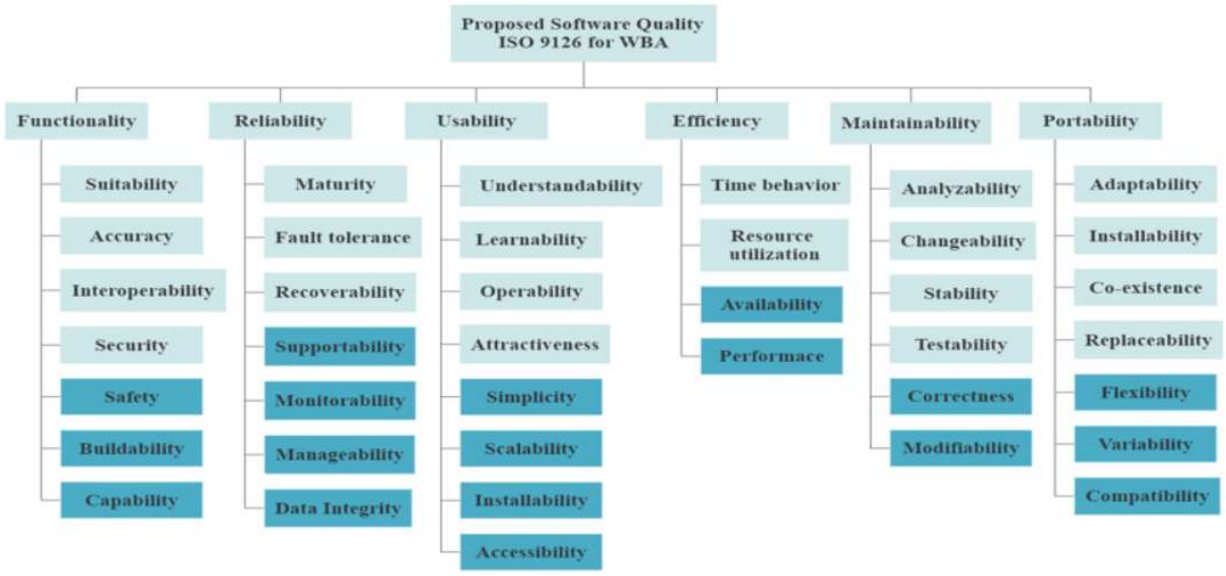

Fig. 2: The Proposed software quality ISO 9126 model for WBA

4.1.1 Functionality

Functionality is one of the most important factors upon which to build any software system. It is the basic requirement for the customer, who focuses on it and realizes its meaning and function. Therefore, it must be concerned with several sub-factors as mentioned in the ISO and explained in the following table.

Table 2: Functionality Sub-factors in ISO9126

Functionality Sub-factors	Description
Suitability	The degree to which a product or system provides functions that meet the stated or implicit requirements when used under specific conditions
Accuracy	The closeness of a measured value to a standard or known value.
Interoperability	The ability of computer programs to communicate with each other for the efficient exchange and processing of information
Security	The concept of implementing mechanisms in the construction of security to help it remain functional (or resistant) to attacks

This study suggests that other sub-factors will be added to help improve the quality of web applications and enable its sub-factors such as safety, buildability, and capability as described in table 3.

Table 3: Added functionality sub-factors for the proposed WBA framework in ISO9126

Functionality Sub-factors	Description
Safety	Improves system integrity in the design, development, use, and maintenance of software systems and their integration with critical hardware systems in the operating environment
Buildability	It is the ability of the available team to complete the system in a timely manner
Capability	It measured and divided into several features to facilitate implementation in a single PI

4.1.2 Maintainability

Maintainability is defined as the ability of an application to be easily repaired, changed, and understood. The maintainable costs the equivalent of 70% of the cost of building the applications. Therefore, the focus on it during the construction of the project starts from the stage of designing the application. Therefore, ISO focused on maintainability and its sub-factors shown in Table 4.

Table 4: Maintainability Sub-factors in ISO9126

Maintainability Sub-factors	Description
Analyzability	This is the ability to identify the root cause of a failure within a program
Changeability	It is an important aspect of robustness, especially in environments that require frequent software changes. This is the amount of effort required to change the system
Stability	The negative effect of system changes is the weakness of system changes
Testability	It means to create test criteria for the system and its component and executes them.

Because of the importance of maintainability for software designers and developers, it is the distinguishing element of any project. If the design is good, the ability to repair will save the effort and time spent by the developers, as well as that cost. The study seeks to impart the essence of improvement to these elements by adding sub-factors such as shown in table 5.

Table 5: Added Maintainability sub-factors for the proposed WBA framework in ISO9126

Maintainability Sub-factors	Description
Correctness	It means that the system do its functions correctly and satisfy all the requirements
Modifiability	It means how many common changes need to be made to the system to make changes to each individual item

4.1.3 Efficiency

Efficiency is one of the basic principles of building information systems. It is represented in the software industry by software requirements divided by number of sources such as time and effort. ISO 9126 has established two sub-factors to evaluate the efficiency of the application as described in table 6.

Table 6: Efficiency Sub-factors in ISO9126

Efficiency Sub-factors	Description
Time behavior	It allows to draw conclusions about how well the time behavior of software is for a particular purpose
Resources utilization	It measures the usage of your available resources. It's an easy way to measure usage and overall business metrics to keep track of your employees' daily productivity

The study has suggested other sub-factors to contribute in improving the efficiency of web-based applications as shown in table 7.

Table 7: Added Efficiency sub-factors for the proposed WBA framework in ISO9126

Efficiency Sub-factors	Description
Availability	It is expressed as the ratio of the available system time to the total working time.
Performance	It is the response of the system to perform its functions in the period

4.1.4 Usability

Usability in software engineering means the degree of software that customers use, taking into account product efficiency, effectiveness and customer satisfaction. We always focus on usability as a key element because ease of use succeeds in systems and attracts customers to them. Usability have several sub-factors for applying as shown in table 8.

Table 8: Usability Sub-factors in ISO9126

Usability Sub-factors	Description
Learnability	It signifies how quickly a new user can begin efficient , error-free interaction with a system and learn how to use it
Operability	It is the ability of the software to be easily operated by the users
Attractiveness	The capability of the software product to be attractive to the user
Understandability	It is the ability of users to understand system functions easily

The importance of usability because it represents the success of the system represented in the application and its use or not. This study strived to suggest a set of sub-criteria to contribute to improving the quality of usability for the user and the site owner, as shown in Table 9.

Table 9: Added Usability sub-factors for the proposed WBA framework in ISO9126

Usability Sub-factors	Description
Simplicity	It means to design the system simply
Scalability	It is the ability of the system to handle load increases without decreasing performance
Installability	It means that the software can be installed easily

4.1.5 Reliability

It is the ability of a web-based application to perform the required functions under constant environmental conditions for a specified period, assuming that the devices and inputs are failure-free. Table 10 shows the sub-factors that used to calculate the web reliability.

Table 10: Reliability Sub-factors in ISO9126

Reliability Sub-factors	Description
Maturity	Software components are proven to be stable by others
Fault Tolerance	It is a process that allows the operating system to respond to hardware or software failures
Recoverability	It is the ability to bring back a failed system to full operation

Reliability is one of the main requirements for modern applications today due to the need for systems to work in different environments, so it was very important to focus on them by adding other sub-factors as shown in table 11.

Table 11: Added Reliability sub-factors for the proposed WBA framework in ISO9126

Reliability Sub-factors	Description
Supportability	It is the ability of the system to provide information when failure happens
Monitorability	It is the ability of the operations staff to monitor the system while it is executing
Manageability	It is the ability of system administrator to manage the system easily.

4.1.6 Portability

Software portability is the use of the web application in different environments. This idea applies to software that is available for use in two or more different platforms or can be reassembled for them. The portability of the program is measured through three sub-factors as shown in table 12.

Table 12: Portability Sub-factors in ISO9126

Portability Sub-factors	Description
Adaptability	It refers to the process adaption of its behaviors to users based on acquired information of its users and the environment
Co-existence	It occurs when two or more systems in different software environments share resources which can be shared simultaneously by different systems in a multi-system configuration, or they can be shared simultaneously by the same system
Replaceability	It is the ability to replace one part of the program in another area. The part that replaces the previous part must produce the same results as the previous part in the entire intended environment

Through the proposed model, three other sub-factors can be added to contribute to improving the measurement and accuracy of the quality model for web applications, as shown in Table 13.

Table 13: Added Portability sub-factors for the proposed WBA framework in ISO9126

Portability Sub-factors	Description
Flexibility	It means the ability of the system to be adapted for different environment and other components to increase the quality of the system
Variability	It is the ability of a software to be adapted for a specific context
Compatibility	It means that the software can perform its required information exchange information with other components while sharing the same hardware/software environment

4.2 WBA as a software stakeholder side

Stakeholders are the key to the success or failure of any application. Therefore, focusing on what they pursue is the main goal of building that. It was necessary to focus on three directions to divide stakeholders according to their priorities: Information technology (IT), whether developers or supporters. In addition, web application owners, and they are the primary element that developers seek because customer satisfaction is the main goal. In addition to the third element of stakeholders, which are, the users and they are the most important element within the organization that often uses and depends on the application to perform their tasks and what they want as shown in Fig. 3.

Fig. 3: WBA as software stakeholder's classification

4.2.1 Information Technology Team

IT team is the differential component within the system building system. According to the software development life cycle, requirement collectors take on the first task by interviewing clients to gather requirements from them and then analysing and making the appropriate diagrams to start the implementation process.
Requirements collectors must be precise in what they collect and purify well because it is the main component of construction. They must focus on the quality of application as a product by applying the following criteria and then applying the sub-criteria for each of them as shown in Fig 4.
It is through these factors that both the web developers and maintainers can measure the quality of the web application.

These factors are the distinguishing and prominent feature that the software quality team must achieve within any web application to ensure its quality.

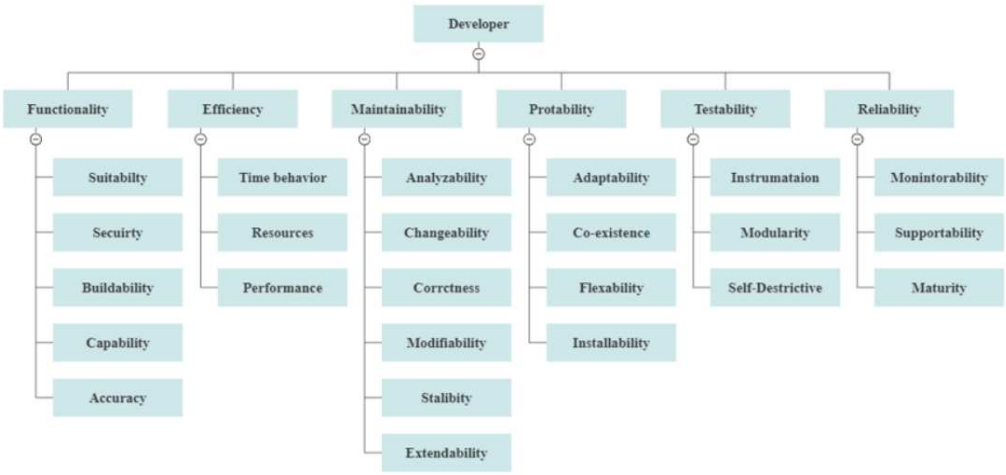

Fig. 4: WBA as software stakeholder's classification

4.2.2 Owner

As mentioned earlier, WBA owners are stakeholders and their role within the system is large and effective. Therefore, through the study, we seek to show their role and identify their priorities and what should be focused on from the ISO 9126 standards during the process of construction and application delivery as well as use and maintenance. Therefore, the study focuses on the criteria of the main factors, interspersed with sub-criteria to contribute to that role, as shown in Fig. 5.

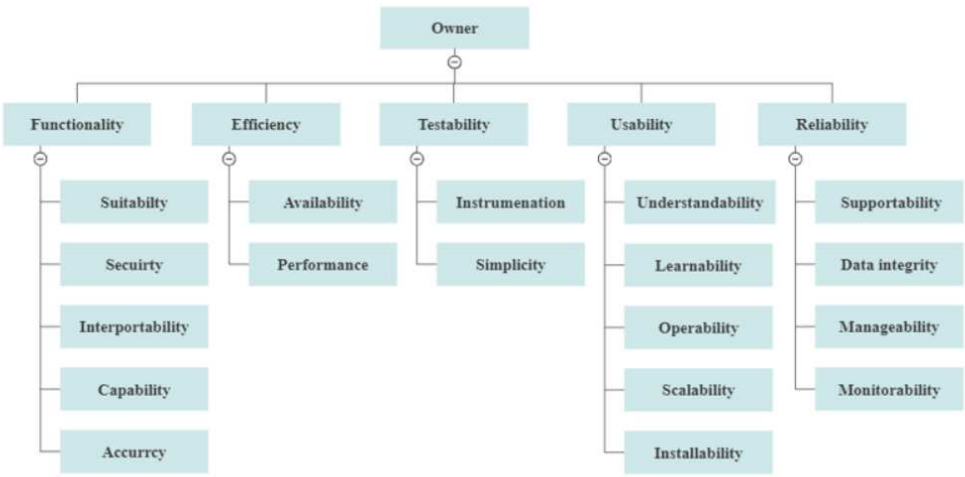

Fig. 5: WBA from the point of view of the owner

4.2.3 User

The user is the key to demonstrating the success of a web application. The demand and dependence on the use of the web from the customers proves to be successful or not, so it is necessary to rely on the user as the main factor and use the sub-factors that relate to it as shown in Fig. 6.

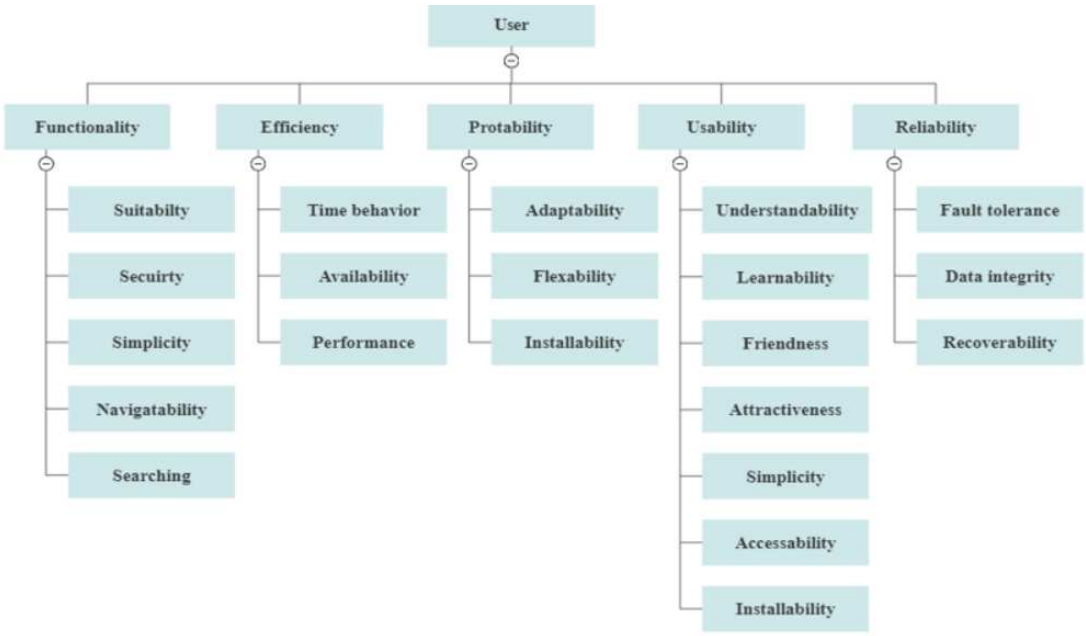

Fig. 6: WBA from the point of view of the user

5 Evaluation and Discussion

In order to confirm the quality of the proposed model we had to evaluate it by users and developers. This section includes the evaluation criteria used in the evaluation, as well as the results of the model

5.1 Evaluation criteria

In order to carry out the evaluation process, a set of questionnaires was created. Survey forms are designed for web application owners; Users and IT team to enable them to evaluate the proposed model with explanation of factors and sub-factors. Two copies of the questionnaire were created, one of which contains Fig. 2 shown in Section 4. The questionnaire consists of 18 questions. Each question represents a sub-factor that is added to the main factor. The user can answer two questions, one of which is about his satisfaction with the added factor, in addition to an assessment of its importance. The other questionnaire contains Figs. 4, 5, and 6 shown in Section 4 as well as 6, 5, and 5 questions for each form, respectively.
A question was also added about the user's satisfaction with the proposal in general. Each evaluator can determine how satisfied he is with the suggestions in the form, as well as the importance of the proposal. In addition to the ability to add a comment that enables him to comment on questions and write notes according to his vision. The ratings of questions range from 1 to 5 according to customer satisfaction with the system as follows:
1. Very unsatisfactory.
2. Unsatisfactory.
3. Good.
4. Very good.

5. Excellent.
In addition to the same degree to assess the importance of the proposal, according to the user's point of view as follows:
1 Least important.
2 Not very important.
3 Important.
4 Very important.
5 Most important.

In order to calculate the evaluation results, the frequency method was used. According to the frequency of users' answers to the questions, whether they are satisfied or not, to their general impression about the quality of the proposed model. User satisfaction or dissatisfaction can be noted on a scale of 1 to 5. If the satisfaction of the users is three or more, the addition will be taken into the submitted proposal. Some additions may need to be improved according to their opinions.

5.2 Evaluation and Results

Two web applications were selected to evaluate the proposed model. The first is an academic college web application and the second is a commercial company web application. The two applications have been selected for their different user categories to cover different levels. Questionnaires were presented to different groups of users; each group consisted of 30 users with explanations of the survey details and websites to avoid ambiguity and objectivity.
According to the questionnaire measurement methods described in Section 5.1, 30 evaluators of the academic web application related to the college filled out the first questionnaire. The results showed the average satisfaction of the evaluators with a large percentage in some questions such as question 8, 12 and 13 related to simplicity, availability and performance, respectively. The ratios also showed the difference of views on some questions, such as 4, 7 questions related to supportability and data integrity as shown in Fig.7.

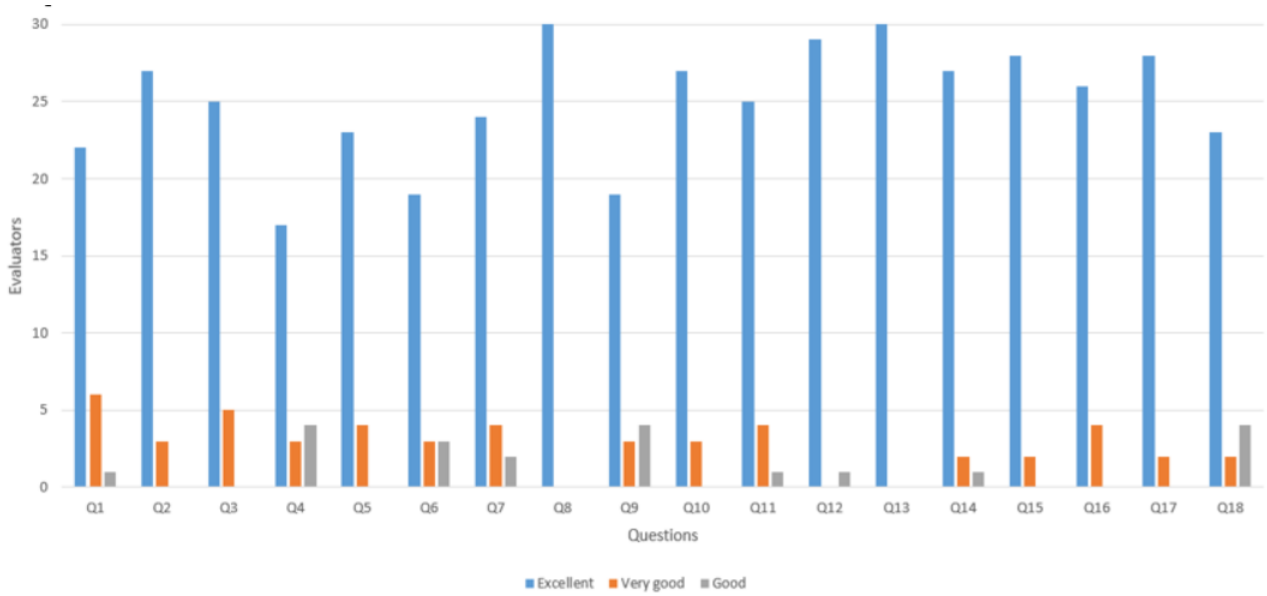

Fig. 7: Frequency distribution of evaluator satisfaction about academic college WBA

In addition to the previous assessment, the same questions were presented to the evaluators to measure the importance of these sub-factors for academic application. The results were promising, as many of them attached importance to the

factors related to questions 2, 7, 8, 13 and 15, which represent buildability, data integrity, simplicity, performance, and modifiability. The study also showed a slight discrepancy in some of the values in question 9, which represents scalability ash shown in Fig. 8.

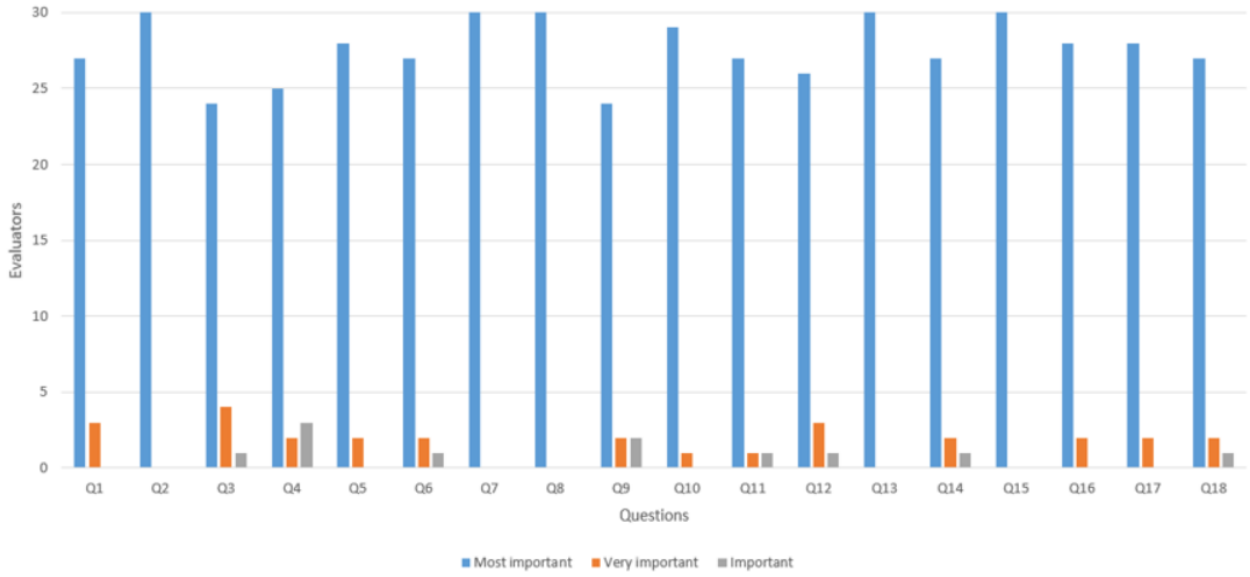

Fig. 8: Frequency distribution of evaluator importance about academic college WBA

The study was also evaluated on a commercial website for a business company for the credibility of the evaluation and its diversity in terms of different categories and business. The experiment was conducted on 30 former residents. The results showed a clear distinction in questions 2, 8 and 12, which represent the factors of buildability, simplicity, and availability, respectively. The study also showed a clear discrepancy in questions 4 and 11 related to supportability and accessibility, as shown in Fig. 9.

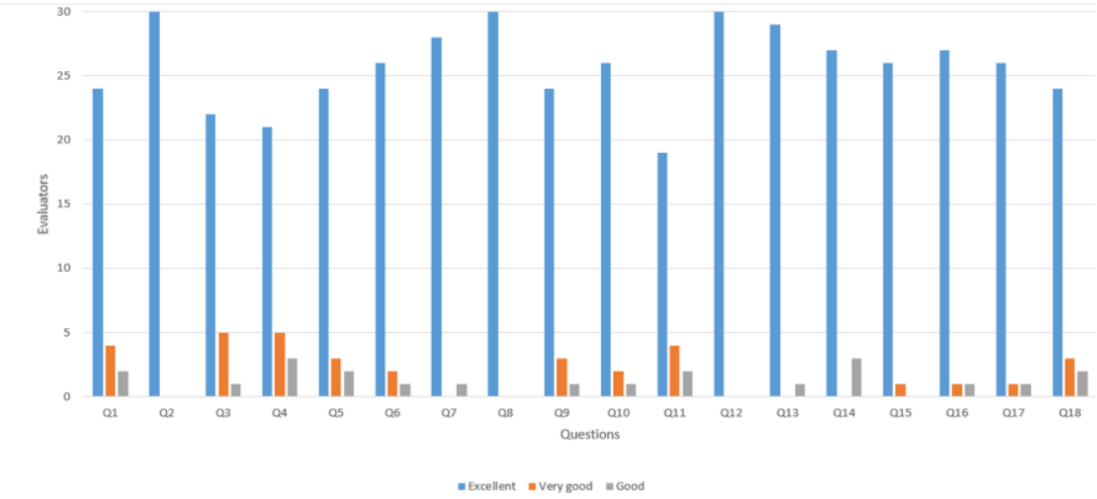

Fig. 9: Frequency distribution of evaluator satisfaction about Business college WBA

The study also contributed to putting forward a questionnaire to measure the importance of the sub-factors for users on the business application. The study was promising in some cases and on the contrary in others. The results showed the importance of some sub-factors such as simplicity. On the contrary, it showed some disregard for factors such as accessibility as shown in Fig. 10.

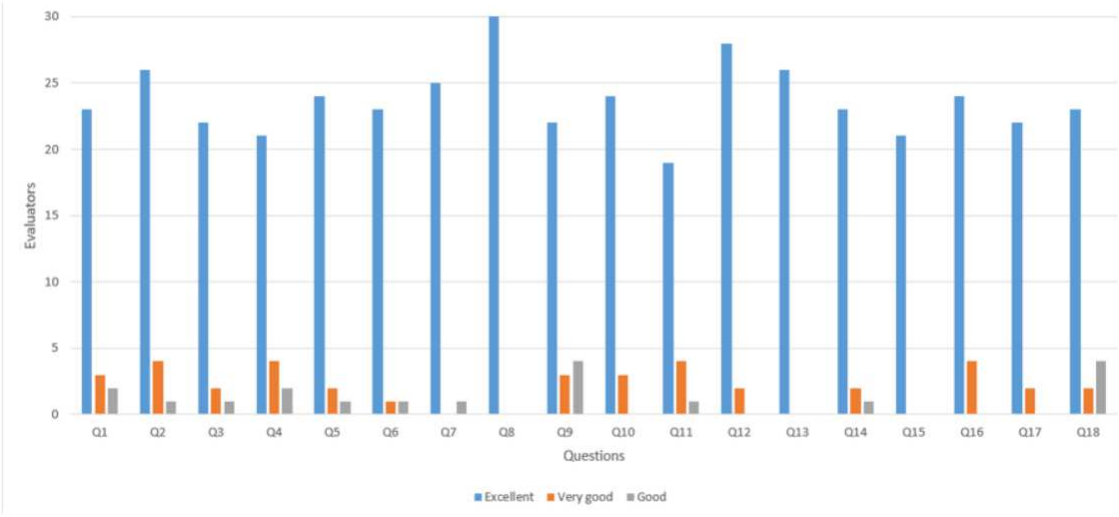

Fig. 10: Frequency distribution of evaluator importance about Business WBA

The results of the previous questionnaires were an important and effective contribution, as evidenced by the evaluation. This was a powerful impetus to do more and create another survey that can be measured by software quality by the IT team, WBA owners, and users. The questionnaire contains Figs. 4, 5 and 6 in addition to the question sets for each model as follows: 6, 5 and 5, respectively. These questions represent the key factors for each stakeholder. The evaluator can determine his satisfaction with this division as well as its importance according to his point of view. Figure 11 shows the evaluators' satisfaction with the proposed model.

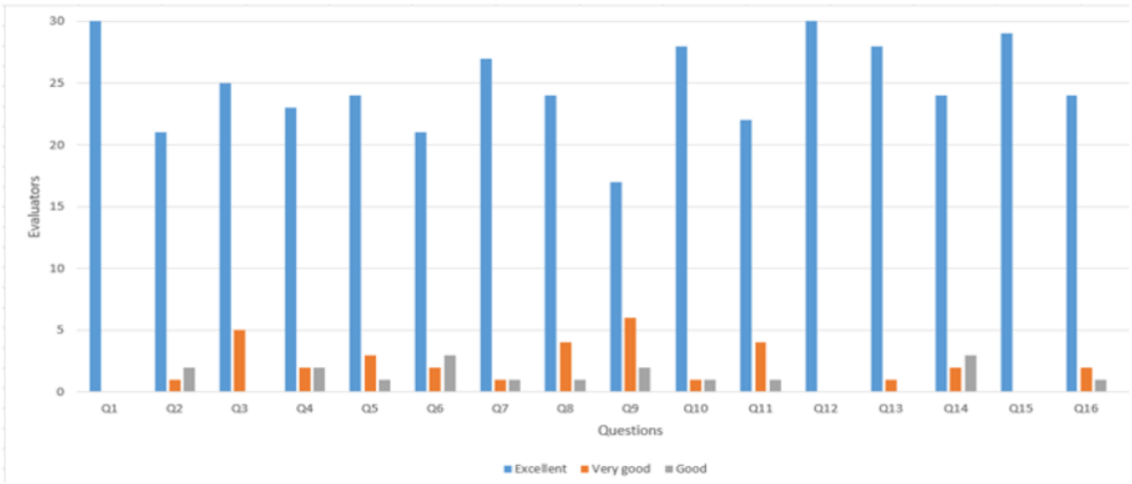

Fig. 11: Frequency distribution of evaluator satisfaction in WBA about software stakeholder side

Through the results of the following questionnaire show. From Q1 to Q6, which represents the Information technology (IT) team. The satisfaction is based on the functionality factor as a main factor in addition to the maintainability factor. From Q7 to Q11 of the WBA owners. Evaluators' satisfaction about the functionality and usability factor shows, with differing opinions about the testability factor.
Attention to the user was one of the main aspects of the success of the evaluation, so his satisfaction was evaluated according to his tasks in relation to the application from Q12 to Q16. The results showed great satisfaction about the factors of functionality and usability. While the results contradicted in the portability factor.
We have also conducted a questionnaire to measure the importance of the stakeholders' factors. The results showed satisfaction among the three according to questions 2, 8, 13 and 15, which represent the efficiency of the Information technology team, the efficiency of the WBA owners, and the efficiency and usability of the users, respectively. While we explained the discrepancy in some factors related to questions 4 and 9 representing the portability of the IT team and the testability of the WBA owners as shown in Fig. 12.

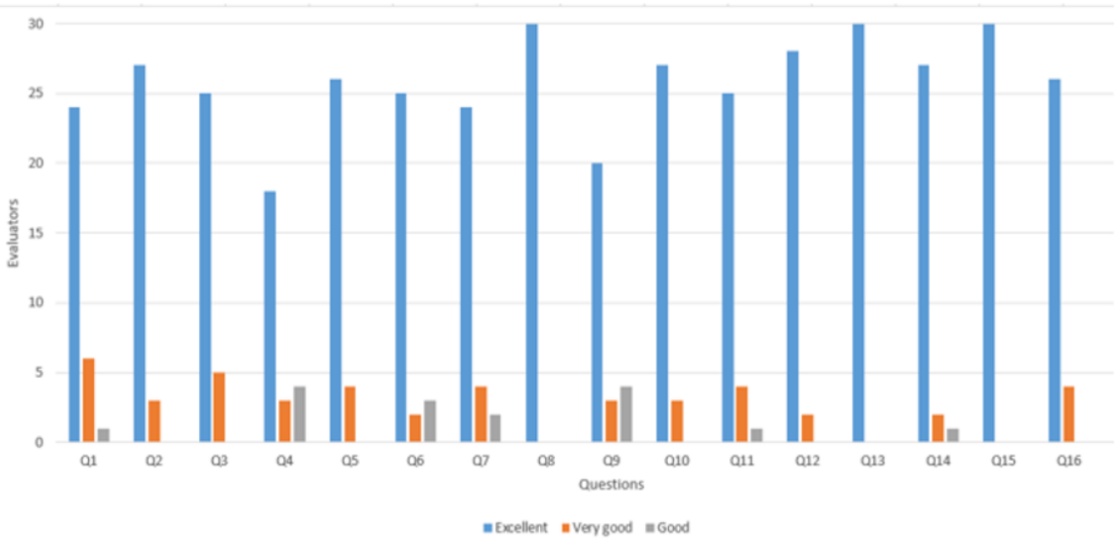

Fig. 12: Frequency distribution of evaluator importance in WBA about software stakeholder side

6 Conclusion

Technology has become the main driver of our world today. Therefore, it was necessary to take into account its importance and role. Technology permeates and drives businesses.
Therefore, web-based applications took a good space and spread prominently, but they faced many limitations such as the lack of experience of developers and the desire to finish projects in record time and others.
For this purpose, this study sought to build a proposed model that enables the measurement and evaluation of the quality of web applications through the ISO 9126 model.
The ISO 9126 model includes six main factors interspersed with a number of sub-factors. Sub-factors have been added to these six main ones to contribute to raising the quality of web applications.
In addition, the stakeholders were divided into three: IT staff, WBA owners, and users. Emphasis was placed on the factors that must be considered by each of them to improve the quality of the product. A set of questionnaires has been made to measure the extent of users' satisfaction with that model. The sample was applied to 30 users. In addition to choosing two web applications, one academic and the other commercial, the results showed great effectiveness with the model and a great desire to implement it in practice.
The average results of questionnaires for a web-based applications that contributed to improving its quality in terms of adding sub-factors to those six major ISOs for the two applications were 91.1% and 89.34% in terms of satisfaction and importance, respectively. Also, the stakeholder questionnaire indicated 89.25% and 88.33% in terms of importance and

satisfaction, respectively. These results are good and promising for the proposed model in terms of the quality of the application and the prioritization of stakeholders. In the future, we seek to apply the model to other WBAs and evaluate it more on the sample more. In addition to distributing the tasks of the IT team according to the life cycle of the software building and assigning a role to each person within the team, the ISO tasks can be directed to the proposed model for it.

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