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HOW TO IMPROVE WEB APPLICATION DEVELOPMENT USING A LAYERED REFERENCE MODEL AND QUALITY INDICATORS

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Abstract: This project proposes the use of a reference model for the software development process based on a Web architecture, this allows the evaluation of the applications developed using different Web frameworks, which are mostly used in IT industry in the region. Through the application of a survey, a comparison of these tools is made using the reference model itself as well as the good practices in the Web development processes that companies use. The characteristics of the tools used allow to be establishing a series of criteria that must be met for the software development process with quality criteria that comply with widely accepted standards. The comparison is made following a research methodology; an analysis-synthesis of the different tools for the development of Web applications in the region was carried out, an exploratory research was also implemented to establish good practices and finally the tests of the most used frameworks.
Keywords: Framework Web; tools comparative; Web Development; FURPS; KPI.

THE MODEL

There is a wide variety of technologies that allow the development of Web applications, the reference model proposed in [1] is used to measure the quality of Web software development, Figure 1 shows the layers and elements. This model is based on a Web architecture (commonly used in frameworks) based on the criteria defined in [2][3]; scalability, efficiency, and utility should be elements of any Web development. In [2] the Model for the development of collaborative integral software (MDSIC) is proposed, which arises from the characterization and good practices carried out in Software factories in the central-western region of Mexico.

The elements of the model are described below:

- FRONT-END. Defines the software

that interacts with the user, interface between the user and the Back-End (platform). It is a mix of languages like HTML, CSS, JavaScript, among others.

- MIDDLEWARE. Connectivity software that offers services that run on different computers over a network (commonly uses the Client-Server model). They hide heterogeneity, abstract away underlying complexity, and provide a convenient programming model for application developers. Languages such as Java Script (JS) and .Net, TypeScript, among others are some of those used.
- BACK-END. It processes the data entry that is made from the Front-End and with the MiddleWare towards the Back-End, this allows the Web software to interact with the information storage technologies implemented. There is a wide variety of languages that are used, of which C++, C#, PHP, JavaScript, Python, among others, stand out.
- PLATFORM. It is the basis for running certain hardware and/or software modules to achieve information storage and interconnection between external components (network operating system). Tools are used for hardware control as well as for communication. The use of platforms such as Windows, Linux, MacOS, among others, stands out.
- QUALITY INDICATORS: They are measurement instruments, of a tangible and quantifiable nature (FURPS and McCall indicators) that can be defined as a KPI (Key Performance Indicator).
- SECURITY. It represents the technologies, methodologies and algorithms that allow to guarantee a safe interaction between the layers of the model [4]. Security technologies such as SSL, VPN, digital certificates, PKI, among others, are used.
- Model-View-Controller. Application architecture that allows better interaction in collaborative development, in addition to providing layered development. It clearly separates software layers helping developers build maintainable code.

With this model, it is then intended to characterize all the Web development approaches (framework), using it as a comparison criterion, which allows evaluating their capabilities, reviewing quality characteristics such as: easy to use, good performance, reliable, that has support, that integrate secure components, using layered development (MVC), and security schemes at different levels. The use of traditional or agile methodologies or models for the development of Web software are not applicable in all projects, rapid development, investing time, money and effort in each of the layers, make developer companies use a framework without having evaluated their capabilities [2]. There are still disadvantages in the use of the different methodologies due to their inappropriate use. In many cases it happens that the human resources that are immersed in the development projects end up working for the methodology, carrying out a number of activities and formats instead of the methodology facilitating the activities that must be developed for the project. It is proposed in this work to show a series of standardized components that allow companies to evaluate the characteristics of the framework that they will use, thereby reducing the learning curve.

STATE OF THE ART

According to literature, a great variety of frameworks for Web development are described, in [1] those that stand out in the

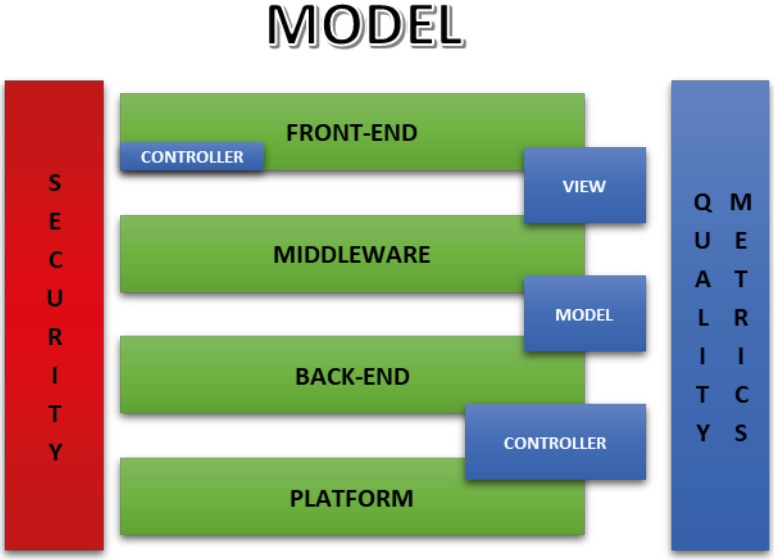


Figure 1. Structure of the Web reference model [1].

Ranking	MEDIUM [5]	GEARHEART [6]	ValueCoders & DZONE [7]	Jet Ruby[8]
1	Angular	Angular	AngularJS	Angular
2	React	React JS	Laravel	Ruby on Rails
3	Vue.js	Vue.js	React JS	Yii
4	Node.js	Meteor	Node.js	Meteor JS
5	Django	Django	Ruby on Rails	Express.js
6	-	Ruby on Rails	Symfony	Zend
7	-	Express	ASP.NET	Django
8	-	-	Yii	Laravel
9	-	-	Meteor	

Table 1. Comparison of Frameworks for Web Development, Top-List]

Indicator / FRAME	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**
Funtionality	5	5	5	4	4	5	4	5	4	4
Usability	5	3	4	4	3	4	4	4	3	4
Reliability	4	4	4	5	5	4	4	4	4	4
Performance	4	4	4	3	5	3	3	4	2	4
Support	4	4	4	4	3	5	4	3	4	4
Total	**22**	20	**21**	20	20	**21**	19	20	17	20

Table 2. Comparison of the best ten Frameworks Web.

industry are obtained, in Table 1 the lists made in [5][6][7][8 are compared.] derived from research projects 1,2.

As an evaluation, software quality indicators or factors are used, under the acronym FURPS: functionality (Functionality), usability (Usability), reliability (Reliability), performance (Performance) and support capacity (Supportability). Table 2 shows a comparison of the ten best evaluated frameworks according to [1]. The evaluation is displayed in the Table 2 following order: I) AngularJS, II) Ruby on Rails, III) React JS, IV) Laravel, V) Node.js, VI) Bootstrap, VII) Meteor, VIII) Django IX) Symfony and X) CodeIgniter.

The methodology that was used to evaluate the model is shown in Figure 2. The definition of a reference model allows to know the minimum characteristics that a framework must offer, with this it will be possible to standardize the use and knowledge of Web technologies in education and in the industry. To validate the model, it is required, -as described in the research methodology-, to carry out a quasi-experiment that consists of comparing the main frameworks with the model, and evaluating them according to the proposed components. The use and evaluation that they use for a Web framework in related projects was investigated in the industry.

As a model validation method, a survey was carried out in the central-western region of Mexico, in companies that develop Web applications and that are part of the SIEM, INEGI and Yellow Section catalogs [3]. According to these criteria, it was found that there are approximately 120 companies (that meet the chosen sample) that are dedicated to the development of Web applications in the region; Aguascalientes with 22 companies, Colima 12, Guanajuato 8, Jalisco 27, Michoacán 24, Nayarit 6, Querétaro 8, San Luis Potosí 10 and Zacatecas 3.

METHOD DESCRIPTION

ANALYSIS OF THE WEB DEVELOPMENT ENVIRONMENT

To determine the most widely used Web development environments in the region, the variables to be measured were defined according to [2] [3] and show in next Table.

The survey was developed with 26 questions, using a Web platform. The questions focused on the elements described in Table 3. They adhered to a Likert scale, in addition to open questions. According to [2], [3] and [10] the calculation of a sample based on the study population is required, using formula (1):

$$\frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1+\left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)} \qquad (1)$$

Where:

N = population size (120)

e = margin of error (5 and 10%)

z = z-score

From this, the size of the sample (companies to be surveyed) is obtained with a confidence interval and a standard error, see next Table.

With this information, the survey was shared among higher education institutions, companies in the region and the government, dedicated to Web development. Of all the companies contacted to answer the survey, a total of 32 complete surveys were obtained (all questions were answered), many surveys were left with questions without answers, so they were discarded. For 32 surveys, the main responses are described below according to the elements surveyed (see the details of the survey in the annex). The Likert scale and the percentage used is: a) Totally Agree 100%, b) Agree 75%, c) Indifferent 50%, d) Disagree 25% and e) Totally Disagree 1%. Figures 3, 4, 5, 6, 7, 8 and 9 show the main results of the survey of 32 companies.

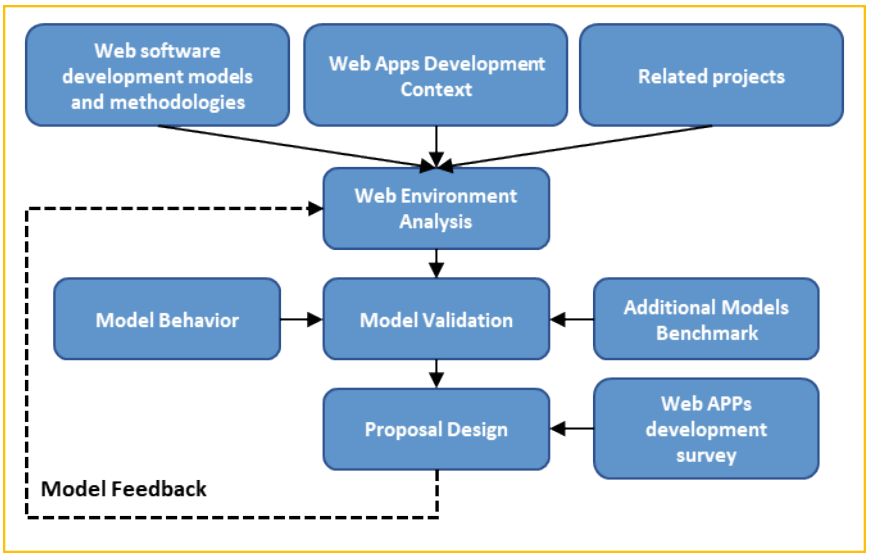


Figure 2. Methodology used to validate the model for the development of Web software [1].

	Element to measure	Description
1	Layers	Development based on MVC Layers
2	Model	Use a model for development
3	Architecture	Use a specific architecture
4	Product	Type of product you develop
5	Technologies	Use of languages or technologies
6	Indicators	Indicators to measure quality
7	Functionality	Product features
8	Usability	Front-End features
9	Reliability	Accuracy and recovery aspects
10	Performance	Response and recovery time
11	Support	Help and documentation
12	Advantages	Framework strengths
13	Disadvantages	Framework weaknesses
14	Reusability	Reuse of code and libraries
15	Security	Security elements and techniques
16	Generalities	General Company information

Table 3. Shows a summary of the variables to be measured in the survey.

Standard error	Reliability interval	Sample size
15%	95%	32
15%	99%	46
10%	95%	54
10%	99%	70
5%	95%	92
5%	99%	102

Table 4. Estimation of the sample population required according to these criteria.

Finally, the opinion of the developers regarding the FURPS indicators was surveyed. Figure 9 shows the result for each of the indicators.

RESULTS

Using the reference model by layers, the evaluation of the main frameworks used in the region was carried out. Bootstrap stands out with 78%, AngularJS with 37%, Laravel with 37%, Node.js with 34% and CodeIgniter with 31%. In the evaluation, a CRUD method (Create, Read, Update and Delete in a Web form) and the FURPS criteria were used. The results are described below:

- Bootstrap. It is used in most companies, because it speeds up Web development tasks in a simple way [12], and according to the assessment made with the FURPS quality indicators, it is an option for the Front-End (design), which should be included as a primary development tool, its use is recommended in an educational environment for Web software.
- AngularJS. It is a great option for creating Web applications, since it is very efficient when creating and especially when displaying the final results. In addition to extensive documentation, thousands of companies have used AngularJS as their base framework. AngularJS may become obsolete with the arrival of Angular [13]. It is very complete and is very useful for those who are starting with the programming of web applications [14].
- Laravel. It has a low learning curve, there is abundant documentation for developer support, it is flexible and adaptable, as well as supporting security and encryption in application development [15].
- Node.js. Its flexibility stands out, since it can be executed in practically all the operating systems, it does not present blocks (high response time intervals), which ensures that it does not block during the execution of the applications. There is a large development community, so there are many manuals and support documents [16].
- CodeIgniter. It is preferred by companies for speed of Web development, offers an advanced range of easy-to-use features. Your goal is to get maximum performance and flexibility with a minimum of code. It is one of the most used and its simple and not complex code stands out [15] [17].

Following the reference model, the comparison was then made, evaluating the development of an application that uses CRUD methods in forms and data access. The facilities of the different languages that are used in the Back-End, in the Middleware and in the Front-End were also evaluated, as well as the platforms that are required as support to run on a server. Finally, the facilities to implement security and development based on collaborative MVC were evaluated. Table 5 shows the results of the comparison.

FINAL COMMENTS

Using the Web reference model allowed evaluating the most important characteristics of the frameworks used in the Web development industry. According to this model we can conclude with the characteristics found in each of the FURPS indicators evaluated, Table 6 shows the three best (AngularJS, Laravel and Node.js).

CONCLUSIONS

When developing this project, what

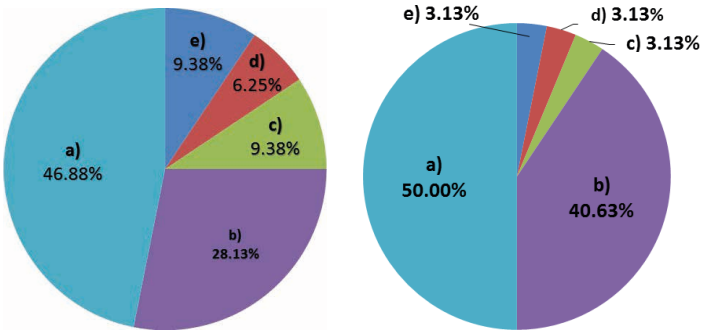


Figure 3. A) Importance of using MVC in developments, B) Use MVC [9] [10].

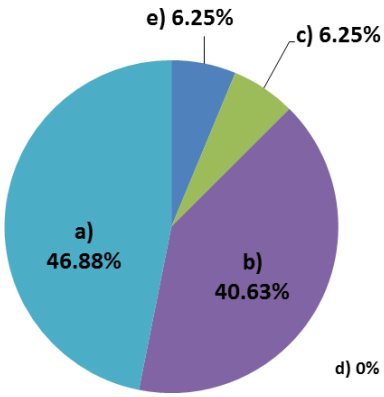
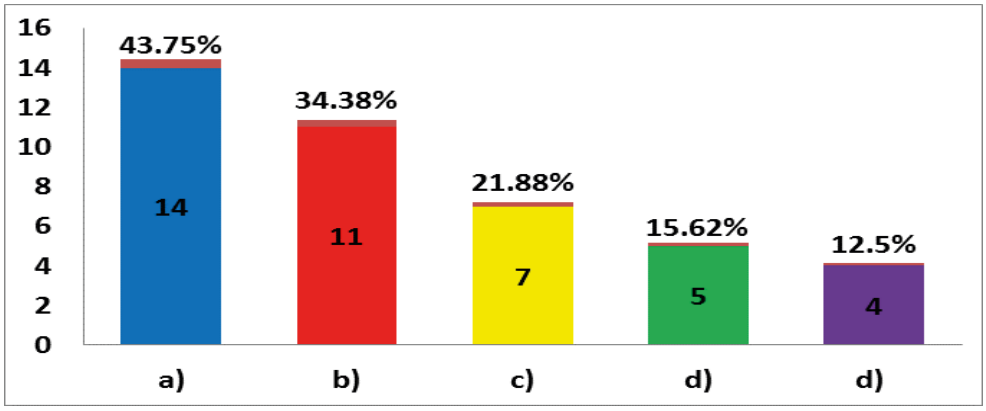
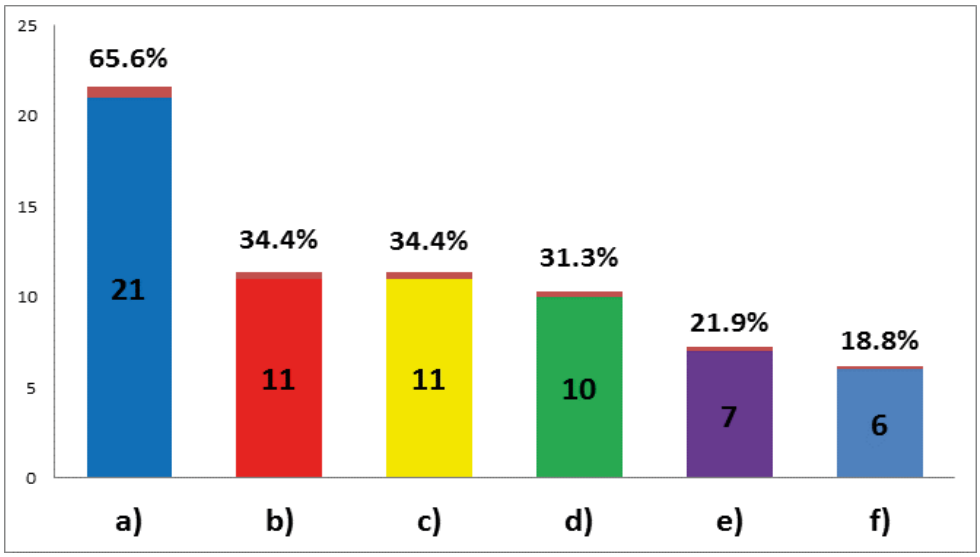


Figure 4. Importance of using a model in your developments [9] [10].



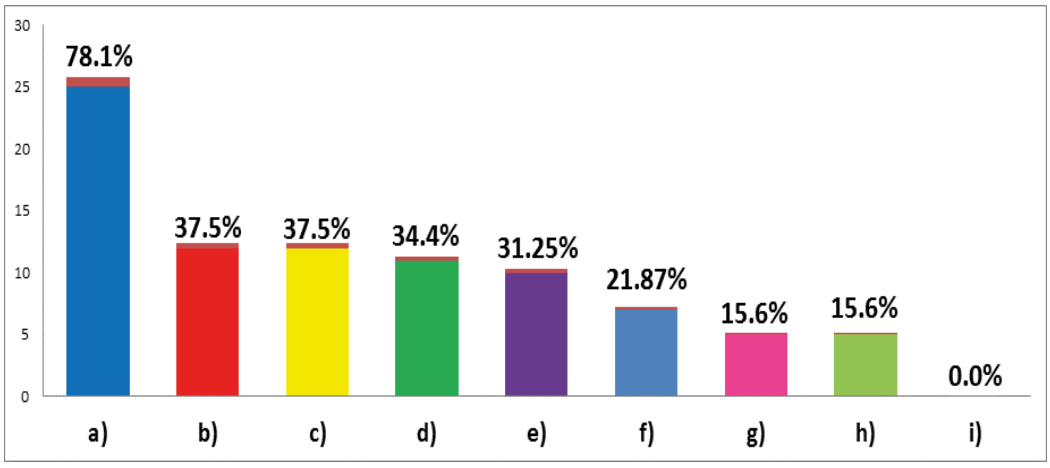
All of the above, b) Web development, c) Development for mobile devices, d) Ad-hoc software, e) Consulting

Figure 5. Turns of the surveyed companies [9] [10].



All of the above, b) CSS, c) JavaScript, d) HTML5, e) other, f) PHP

Figure 6. Technologies used by companies [9] [10]



a) Bootstrap, b) AngularJs, c) Laravel, d) Node.js, e) CodeIgniter, f) React JS, g) Django, h) Others, i) Does not use frameworks

Figure 7. Most used frameworks [9] [10].

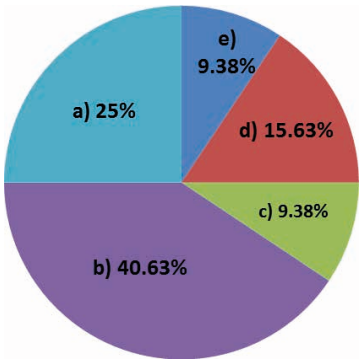
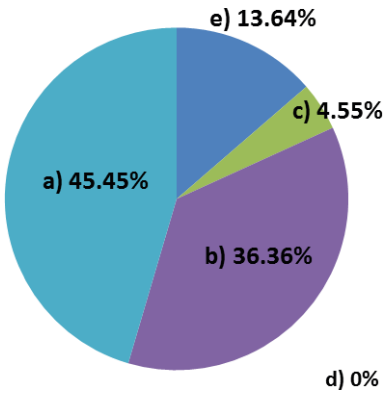
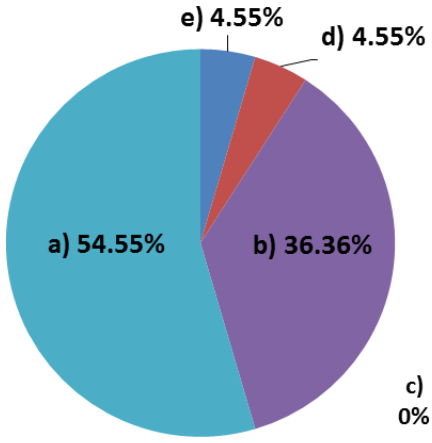


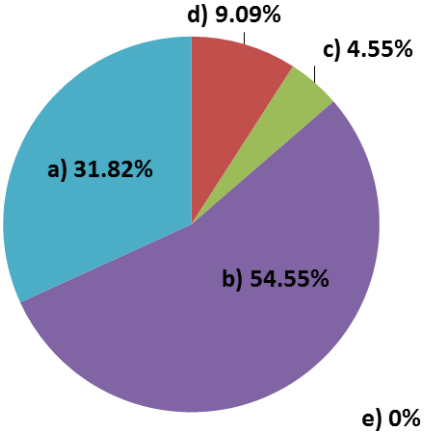
Figure 8. They agree with the census of quality indicators in development frameworks [9] [10].



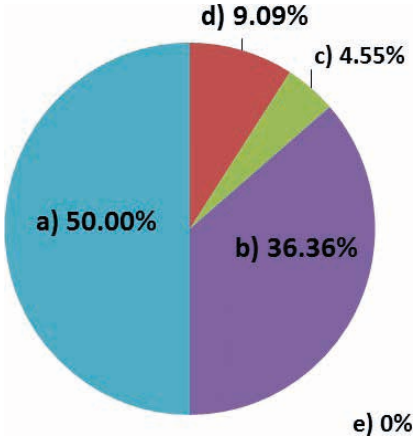
A) Functionality



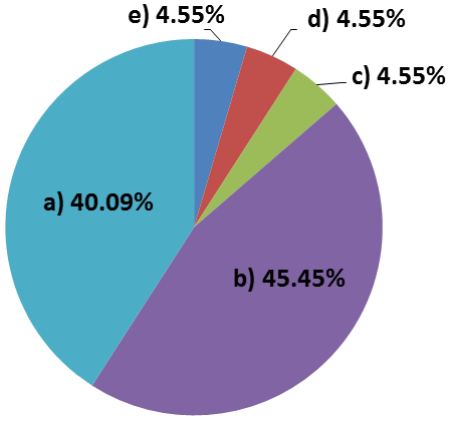
B) Usability



C) Reliability



D) Performance



F) Support

Figure 9. They agree to use FURPS (A-F) indicators in a Web development framework [9] [10].

	Boostrap	AngularJS	Laravel	Node.js	CodeIgniter
Security	Medium	Medium	Medium	Medium	Low
∑ FURPS	25	25	23	22	20
MVC	Use layers	Use layers	Use layers	Does not use MVC, although it can be built	Use layers
Plataformas probadas	Chrome, Edge, Firefox, MySQL, Postgres, MongoDB, *FireBase*	Chrome, Edge, Firefox, Windows, Linux, MongoDB, Firebase	Chrome, Edge, Firefox, Windows, Linux	Chrome, Edge, Firefox, Windows, Linux	Chrome, Edge, Firefox, MySQL, Postgres, Windows, Linux
Front-End	CSS3, HTML5 y JQuery	HTML5, CSS3 y JS.	CSS3, HTML5 y JQuery	HMTL5, CSS3, JS	CSS3, HTML5 y JQuery
MiddleWare	JS, JSON	PHP	Node.js Express	Node.js	JS, JSON
Back-End	PHP, PERL y JS	JS, PHP. Python, Ruby	JSX, XML, HTML, Node.js	Java, Python, Ruby, JS, Go	PHP, PERL y JS

Table 5. Validation of Frameworks used in The Region and using the Model [1] [10]

SUMMARY OF RESULTS

Framework	Functionality	Usability	Reliability	Performance	Support
AngularJS	It allows to use dynamic information for the creation of Web applications. It uses jQuery Lite elements where the DOM manipulation is required. It has debugging tools.	It can be difficult for a newbie to start using it, because they have to learn JS or TypeScript. Models are plain JS objects, so it makes it easy to transfer data between the application and REST services or LocalStorage. It also reduces the complexity of getter and setter functions. It has a friendly project generator.	Dependencies may be lost when updating the framework Views may update automatically when an observable object changes. The use of libraries and templates give greater reliability.	Render the same code differently in web browsers and mobile apps. Smaller file size results in faster upload and download times. It has a mechanism to filter views based on scope variables, without the need to write a lot of extra code. Fast charging time.	The AngularJS Web page has a good design, it has installation and getting started guides to use it. It has programs that offer simple functionality to sync models with LocalStorage and HTML5. Browser version and compatibility can be important when managing projects.
Laravel	Defining, logging and listening for events in the application is very easy. The "listen" property of "EventServiceProvider" contains a list of all the events registered by the application, helping a simple and fast development	Good and abundant documentation, especially on the official site. Apps offer a robust caching system, which can be tuned to make the app load faster for the best user experience.	It is modular and with an extensive system of packages and drivers, with which functionality can be extended easily, robustly and safely. Implement user authentication natively. In addition, it allows to include additional parameters, which will secure the active user. It has everything you need to use OpenSSL security and encryption AES-256-CBC.	The Blade template system offers improvements in the presentation part and the generation of simple and clean code templates. It includes a cache system that speeds up and improves the performance of an application. It facilitates the management of routes (path) of the application, friendly url generation and control of self-updating links, which makes maintenance easier.	Flexible and adaptable not only to traditional MVC, it proposes the use of "Routes with closures". It has a large community and help forums.
Node.js	It can support tens of thousands of concurrent connections. You can use JS as a scripting language in the console. Allows you to use JS, both on the client and on the server.	The applications are faster and therefore the user experience is better. Its resemblance to JS and the DOM makes this language easier to learn.	It guarantees that you will never deadlock, because locks are not allowed, and because you don't directly use calling an I/O device.	Unit test execution can be done faster. It maintains an Event Loop that handles all asynchronous operations. It is possible to program on the server, access to data, databases, client connections, among others.	Lower infrastructure cost. Its flexibility stands out. It can run on a variety of servers, including Windows, MacOS X, and Unix. There is a large community that supports documentation, making tutorials and creating new modules or improvement.

Table 6. FURPS of the Main Evaluated Frameworks.

was observed is that building applications following a standard model can be an ambitious goal, but it can be simplified using a methodology. In the analysis of the different web development frameworks that exist in the market and their comparison, it becomes clear why there are so many different frameworks and one of the main reasons is that they serve different types of needs and are adaptable for different projects. They can even use different technologies and in the same framework using the same design pattern, this helps the development of similar projects. The tools that can improve the delivery time of a project will always be up to the developers.

The software quality models, although they have some differences between them, have many more similarities and help to evaluate many of the aspects that must be taken into account to achieve a good Web software development, and end with this a product that complies with quality standards.

On the other hand, when analyzing the results of the survey, it can be seen that nowadays it is very usual and even necessary to use a software architecture to base it on when carrying out projects. In the industry there is extensive use of MVC, but there is also the MVP (code pattern) or MVVM, used in increasingly collaborative development environments.

The reference model and the indicators to make comparisons become a benchmark in the industry, it is very important that from the learning of these tools the different elements are taken into account to achieve quality development. As future work, the need to evaluate the different Web development environments in the security elements is observed, for each one of the layers, the hacker attack for this type of software development is becoming an important factor to consider.

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APPENDIX A. VALIDATION OF THE SURVEY USED IN THE RESEARCH

Cronbach's alpha: It is a coefficient that is used to measure the reliability of a measurement scale (in this case the survey), and whose name alpha was given by Lee Joseph Cronbach. To calculate Cronbach's Alpha, the formula 2 that appears in formula 2 is used and with the following meanings for the variables:

· α= Cronbach's alpha
· n= Number of items
· Vi= Sum of the individual variances of each item (question)
· Vt= Variance of the total sum of each individual (respondent)

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_i V_i}{V_t}\right)$$

Formula 2. Calculation of Cronbach's Alpha

At the time of the survey, questions were included that, given their formulation, the answer should be given based on a Likert scale, which allowed us to measure the degree of conformity of the respondent based on the question asked. To carry out a more precise measurement, the following values were used for the answers to the different questions:

· Strongly disagree = 1
· disagree = 3
· indifferent = 5
· Agree = 7
· Totally agree = 9

Having these values already assigned to each response, the calculation is made to obtain the variances. Table A1 shows the calculation made and Table A2 shows the detailed information of each item and each individual. It should be noted that in order to:

No. of elements	n	10
Sum of individual variances	Vi	38.597
Variance of the total sum of each individual	Vt	161.524
Section 1	n/(n-1)	1.111
Section 2	1-(Vi/Vt)	0.761
Cronbach Alfa	**α**	**0.846**

Table A1. Calculation of Cronbach's alpha.

Applied survey. August-November 2018. e-encuesta.com. Likert scale used, see Table A2:

· strongly disagree
· In disagreement
· Indifferent
· In agreement
· Totally agree

Questions	Respuestas
1.- Is the MVC (View Controller Model) architecture important for your company within your Web development when using a framework?	Likert scale
2.- In the development of Web software, do you use the MVC (Model-View-Controller) architecture?	Likert scale
3.- Do you use the MVC architecture for the development of your products or services?	Explain:
4.- Is the use of the MVC architecture important to you when using a framework?	Likert scale
5.- Would you use a reference model (a tool that helps propose a method or steps, called good practices) for the development of Web applications?	Likert scale
6.- Which of the following options best describes the work that your company does?	Web development Mobile web development Consulting All of the above Other
7.- Select which of the following technologies are used for the development of your products or services.	HTML5 CSS JavaScript PHP All of the above Other
8.- Do you use any framework to carry out your software development activities? And if so, which framework(s) are you using? (If you use a framework that does not appear among the options, select the last option and indicate which framework(s) you use)	No. Uses frameworks Angular JS React JS Bootstrap Code Igniter Django Node JS Laravel Otro
9.- Does the framework used in your company make use of quality indicators that allow you to measure the quality of your processes, products or user satisfaction?	Likert scale
10.- Do you think there is a direct relationship between MVC and the framework used?	Explain:
11.- The functionality is defined as all the functional requirements of the entire system that we would expect to see described. These generally represent major product features that are familiar within the business domain of the solution being developed. Do you consider that the framework you use is functional?	Likert scale
12.- Usability includes observing, capturing, and establishing requirements based on user interface problems: aspects such as accessibility, interface aesthetics, and consistency within the user interface. Do you consider that the framework you use is usable?	Likert scale
13.- Reliability includes aspects such as availability, accuracy, and recoverability, for example, calculations or the system's ability to recover from power-off failures. Do you consider that the framework you use is reliable?	Likert scale
14.- Performance involves such things as the performance of information through the system, the system response time (which is also related to usability), recovery time, and startup time. Do you think that the framework you use has good performance?	Likert scale
15.- Supportability includes a series of other requirements, such as testability, adaptability, maintenance, compatibility, configuration, stability, scalability, localization capacity, etc. Do you consider that the framework you use has a good support capacity?	Likert scale
16.- What advantages do you consider that the framework you use presents in the company you work for?	Open answer

17.- What disadvantages do you consider that the framework you use presents in the company you work for?	Open answer
18.- Based on the FURPS scale, what do you consider to be the most complete framework for your needs when developing? Why?	Open answer
19.- Does the framework commonly used by the company you work for promote code reuse? Why?	Open answer
20.- How good do you consider the security of the framework you use (based on the FURPS scale)? Why?	Open answer
21.- When choosing a framework, what do you rely on to be able to use it?	Open answer
22.- Select which state of the republic the company where you work belongs to. States/ Departament of México country.	Colima Guanajuato Aguascalientes Jalisco Michoacán Nayarit Querétaro San Luis Potosí Zacatecas Otro
23.- Indicate the number of employees of the company where you work	1-10 11-50 51-200 More than 200 I prefer not to answer
24.- Name of the person who answered the survey	Open answer
25.- Position of the person who answered the survey	Open answer
26.- Email of the person who answered the survey	Open answer