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Comparison of development methodologies in Web applications.

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Abstract.

Context: Web applications development is at its peak due to the advance of technological trends and the constant dependence of the Internet. As a result of the needs of developers, new development methodologies have emerged. However, that does not mean that companies always implement an optimal development process; instead, there are several disadvantages presented by an inadequate and not versatile methodologies.

Objective: The aim is to compare web development methodologies based on dynamic features presented during the life cycle to identify their use, relevance, and characteristics. The process employing is an SLR and field research to Ecuadorian development companies.

Method: The method used is a systematic literature review (SLR) for the identification of characteristics and processes of development methodologies. Additionally, a survey of Ecuadorian web application developers was implemented to assess the importance of using a method during the project.

Results: The literature review exhibited as a result that UWE and OOHDM have greater flexibility than other methodologies before dynamic environments during the web development process. On the other hand, within field research was obtained that companies use different software development methods than those assessed in the study (hybrid methodologies). However, within the range of companies using the compared methodologies, UWE is the most selected.

Conclusions: Each methodology holds particular features and employment environment, which makes them useful in specific conditions. Through the field research, it is possible to conclude that most of the companies use different methodologies than the evaluated ones; thus, the process is guided by hybrids methods or models based on experience. On the other hand, through the SLR, we identified UWE as the most suitable methodology for web development under dynamic environments, such as the size of the company, the need to modify the requirements, or the knowledge that the development team has about the process.

Keywords: *Development methodologies, web applications, comparison, agile methodologies.*

1 INTRODUCTION.

Due to the global growth of companies and their link with new technological trends, software development has immersed in constant change. Methodologies used for traditional applications are not efficient for the development of web applications because they leave out relevant features that this kind of system has.

The emergence of new development methodologies arises from the need to satisfy the concerns of developers during the process. Some issues considered are the life cycle, characteristics features of the web application, and different environments that developed companies present.

Developers use agile methodologies on a large scale, due to their facility to solve problems during the process, such as constant changes of requirements by the client, lack of security, design issues and implementation of the system components.

As application requirements increase, development methodologies evolve. Within the Ecuadorian market, the number of development companies, as well as independent developers, has increased significantly. However, the development process has shortcomings, delays in deliveries, and difficulty with changes.

The use of an adequate methodology during the project is a critical point to achieve a quality application. Nonetheless, the large number of emerged methodologies and complexity of web application implies a challenge at the time to select a developed method. There is a great diversity of studies that compare development methodologies, but few contemplate the dynamic characteristic features of web systems.

For this reason, an SLR is carried out to compare the methodologies (OOHDM, RMM, WebML, SOHDM, OOHDM, UWE, and Hera) based on

specific characteristics and difficulties arisen during the development process.

The systematic review conducted considers techniques and guidelines used within other SLRs. Nevertheless, field research was added to answer the aim of the article, which implies the ascertainment of the use of methodologies within the Ecuadorian development market, also its degree of implementation and relevance within the process.

Unlike other SLRs, the research conducted compares results obtained within the literature and opinions that developer companies considered by the survey. Under those circumstances, we use an SLR to identify the features under which methodologies can be efficient, including project size, requirements, and development team, selecting the most suitable according to theory but how do we know if companies follow the guidelines of a methodology to develop a web project?

For those circumstances, we surveyed developer companies in Ecuador that allowed us to know whether the methodology with greater use in practice is the same from developers, as from authors of the literature, as well as, the difference, similarities, and the degree of involvement.

As a consequence, the main objective of the research is to compare web software development methodologies based on dynamic environments presented during the life cycle to identify their use, relevance, and characteristics during the process; through an SLR and field research to Ecuadorian developer companies. Besides, to propose the most suitable methodology for dynamic development processes, considering indicators that affect their employment, such as the type of company and type of project.

The rest of this document is structured as follows: Section 2 presents the framework used for the analysis of related research. Section 3 provides the search methodology used to classify and analyze primary studies, while Section 4 exhibits a description of web development methodologies selected. In Section 5, we present the results of the comparison and field research. Finally, Section 6 provides a discussion of the findings, followed by conclusions and future work in Section 7.

2 BACKGROUND

2.1 Web engineering.

Web engineering is the set of methods and tools that allow the development of web systems in a less complicated way, also handle the navigation structure, security aspects, and requirements of quick change that web projects have before other software [1].

According to Dominguez *et. all* [2], web engineering rest on a model-driven development paradigm (MDE), in which developers and end-user built the application together [3]; due to the flexibility that characterizes the web development process. The communication between the user and the work team is necessary to identify any existing modification in initial requirements.

The aims to employ models within the process are "to improve the ability to deal with data and business logic, and strengthen the management of presentations"[4]. Due to the immense advantages, a large number of developers seek to evolve the existing development process, by model-based methods.

2.2 Web applications.

According to Mesbah, Betin-Can, and Mirshokraie [5], a web application like a traditional software requires development processes that involve the collection of requirements and programming through different languages, which leads to heterogeneity in its development. Because of this, it is possible to consider web applications as "a system that generally consists of a database (or back-end) and web pages (the front-end), with which users interact through a network using a browser"[6].

There are two types of web applications, dynamic or static ones, depending on the action that the user's input requires. Due to their rapid development and benefits are used by the e-business world, such as digital stores or banks, allowing the interacting between end-user and the page content.

Al-Salem and Samaha [7] define some characteristics of web applications including, volatile requirements, the many and unknown end-users, the multiple stakeholders, the complex content, and the short development life cycle. The

delivery period is usually three months or less, although their process is complex, and each stage presents different challenges.

2.3 Traditional development methodologies.

The aim of traditional development methodologies is "assessing fully specified problems rigorous planning, predefined processes, and periodic documentation" [8] during the process. Chan and Thong's research [9] specifies that traditional methodologies start from two assumptions, (1) customers do not know the requirements, and (2) developers must incorporate functionalities that will satisfy the customer's needs.

Agile development methodologies.

Compared to traditional SMDs (Software Development Methodologies), the agile ones implement new forms of development, so companies prefer their use during the project. Developers consider them as "a new source of methodologies that aim to overcome the limitations of traditional plan-based SMDs"[9].

According to Senapathi and Drury Grogan [10], the use of agile methods nowadays has generated a significant impulse within software development, considered as a fully viable approach in professional and academic spheres. The guidelines established in the agile manifesto [11] allow the development group has elasticity and ease during the process.

2.4 Web application development methodologies.

The development of web applications differs from the process of traditional ones due to specific features that web projects have, which makes the maintenance and development process more complicated.

As in traditional applications, there are different methodologies for the development of web applications that evolve as the complexity of the project increases. Commonly, developers prefer methods based on previous projects and architectural patterns such as the view-controller model, which uses the unified modeling language (UML) and meta-models.

Ginige and Murugesan [12] specify in their research that web methodologies, like other ones, follow a series of stages since the conception, development, implementation, performance evaluation, and ongoing maintenance.

3 RESEARCH METHODOLOGY.

The information search and analysis process used during this study focus on the methodology applied in Kitchenham *et. all* research [13]. The study aims to compare web development methodologies using systematic literature reviews (SLR) and a survey to support the results founded.

To achieve the aim of the study, it has two kinds of research: (1) bibliographic research to collect the information necessary, and (2) field research based on a survey as a tool for collecting data.

- **Bibliographical research:** we select it to analyze the literature of other authors about web development methodologies whereby an SLR, and then compared them.
- **Field research:** We used a survey, as a collection tool, to acquire the necessary information and determine the most used web development methodology by Ecuadorian development companies.

Both methodologies help to contribute significantly within the results of the research One of the issues raised within the research is the need to know the use and relevance of development methodologies within the scope of Ecuadorian development (through the survey). Therefore, it is necessary to identify the characteristics and employment of each one through a literature review.

Another purpose posed is to propose the most suitable methodology according to specific features that web projects have, and the conditions of employment. Therefore, it is necessary to carry out an SLR to obtain a comparison based on selected indicators, and as a result, determine the methodology with greater efficiency. On the other hand, with the survey, we verified whether development methodologies have the same results within the development scope in Ecuador.

Additionally, through the survey, it will be possible to identify if the use and importance of the methodologies within the developer companies maintain the same degree as the relevant stages identified in the literature.

3.1 Research questions.

The study presents two approaches, the first based on the importance of the use of software methodologies, and the second focused on the most suitable method for the development of web applications according to the needs of the project.

Based on the above, two research questions are stipulated, analyzed from different perspectives.

RQ1: Are the web software development methodologies found in the literature used by Ecuadorian development companies for the fulfillment of quality web projects?

RQ2: What is the best methodology for developing web applications under dynamic environments?

> **RQ2.1:** What are the processes immersed according to different authors within each of the stages of the development methodologies?
>
> **RQ2.2:** What modeling tools does the methodology used throughout the process?
>
> **RQ2.3:** What benefits does it provide to the necessary features and dynamics of the life cycle from developers and authors of literature?

It is necessary to consider three evaluation approaches to answer the RQ2: (1) the life cycle, (2) the tools, and (3) the characteristics of each methodology.

Through RQ2.1 and RQ2.2, it is possible to identify the methodology that addresses all the needs and difficulties that a project presents during the life cycle.

The research question RQ2.3 was formulated to select a development methodology that can be applied under specific conditions, thus, to know the circumstances for optimal use. Does the type and size of the development of company influence? If the requirements vary frequently, or if the interested parties require greater importance within the project? Does the use of the selected methodology affect? Based on those apprehensions, the aim is identifying not only the one with the best tools or processes but also the one that developers can employ under specific circumstances.

In this way, it is possible to cover some relevant issues when developers have to select a methodology. Due to considerate the fundamental pillars of the development process, like the life cycle, the tools, models used, among other features referring to the dynamism in the development process.

3.2 Selection of web development methodologies.

We established two processes to select the methodologies to be compared.

(1) First, a study was necessary to acquire knowledge though in the academic sphere in educational institutions in Ecuador. Because new companies start using methods of which they have previous experience.

(2) Then, we implemented a pilot survey of national software companies to verify the application of the methodologies previously researched. In the case of identifying a new development methodology with high recurrence, we will consider it within the field research.

It is important to emphasize that the selection process within the pilot survey was random; in other words, there were no criteria considered to filter the results.

The results of the pilot survey defined a new methodology with recurrence, which was WebML, while other ones, such as WebRatio, WSDM, WAE, NDT, and other new ones, had a minimum magnitude, so we did not consider them within the study.

Finally, and after an exhaustive analysis we decided that the methodologies selected to the comparison are: OO-H Method (Object-Oriented Hypermedia Method) [14], RMM (Relationship Management Methodology) [15], WebML (Web Modeling Language) [16], SOHDM (Scenario-Based Object-Oriented Hypermedia Design Methodology) [17], OOHDM (Object-Oriented Hypermedia Design Model), UWE (UML-Based Web Engineering) and Hera.

3.3 Review Protocol

The process contemplated throughout the systematic review of the paper's literature consists of three phases:

1. Exploration phase: This process considers the research of literature and the gathering of possible primary studies. Also, identify the search strings, and inclusion, and exclusion criteria.
2. Primary studies selection phase: This stage analyzes each paper obtained by categories and then presents the useful researches for the comparative study.
3. Phase of evaluation and data extraction: This consists of determining the process for gathering and analyzing the information obtained from the primary studies.

The review protocol was carried out by the authors, thus assuming the role of information extractors and reviewers, as well as performing the pilot test to validate the development methodologies proposed in this study.

3.3.1 Validation of Review Protocol.

For the validation of the review protocol, both authors and an additional external collaborator perform a pilot test. Therefore, the process contemplates the following activities, which tended to be repetitive.

1. Arbitrary selection of studies for evaluation.
2. Use of the extraction form to obtain the information of each selected study.
3. Validate the parameters within the form. If there are changes, authors repeat this step.

3.3.2 Search process.

Based on the research methodology employed by Dik, Paasivaara, and Lassenius in the study [18], we conducted four phases to gather the information in the databases.

- **Phase 1.** Search for studies in digital libraries.
- **Phase 2.** Elimination of duplicate references, by date range, and inclusion and exclusion criteria.
- **Phase 3.** Classification of information according to the issues**.**
- **Phase 4.** Analysis of the data based on the research questions.

3.3.2.1 Data search.

One of the most commonly used methods of searching for research and related work is the selection of archives within digital libraries.

To have a more inclusive search, we used several libraries presented in Table 1.

Table 1 Digital Libraries

N°	Library
1	Science Direct
2	Springer Link
3	IEEE Xplore Digital Library
4	ACM Digital Library
5	Academic Search Complete

Important to realize that we considered Since Direct and Springer Link as the main libraries due to their broad range of documents, which involve development methodologies and Web Engineering.

3.3.2.2 Search strategies.

The foremost strategy used in this study was the setting of terminology to gather possible researches and studies. Key terms were related to RQ2 because its results come from the literature. Table 2 shows the keywords used within each research question.

Table 2 Key Terms

RQ	Terminology
Development Stages	"life cycle" OR "development process" AND "web methodology"
Modeling tools	"develop " AND "web applications" OR "UML" OR "modelling" AND "web methodologies"
Methodologies features	"Stages" OR "features" OR "benefits" OR "consequences" AND "web methods"
Methodologies approaches	"Approach" OR "task-driven approach" OR "content-driven approach"

3.3.2.3 Inclusion and exclusion criteria.

The inclusion criteria considered are:

- The focus of research is related to web engineering.
- Research is within the domain of established libraries.

- The year of publication is from 2000 to 2019.
- The language of the research is English or Spanish.
- The research is of the revision or publication article type.

The exclusion criteria considered are:

- The metadata provides sufficient evidence that the study is not related to web development or engineering methodologies.
- The summary does not provide sufficient information or evidence to indicate that the research does not have an approach related to web application development methodologies.

3.3.3 Study selection and classification.

We used quality metrics to categorize potential studies as valid, doubtful, and Invalid. The criteria considered in each classification of the primary studies are the following:

"Valid": Studies that meet the inclusion criteria, and possess high reliability in terms of the metadata provided.

"Doubtful": Studies with little reliability in terms of metadata obtained, and results of little relevance to research.

"Invalid": These are studies that do not meet the inclusion criteria, and has no relation to the research approach.

Fig 1 presents the search process by refining the set of possible studies identified from the database search.

During phase 1 (search for information) an estimated 189 investigations were raised, including review papers, and conference proceedings. In Phase 2, a total of 43 articles were filtered by publication date range, inclusion criteria, and duplicate documents. Also, 87 papers about conference proceedings were eliminated.

Phase 3 left a total of 55 items available to be classified according to the categories shown in Table 3.

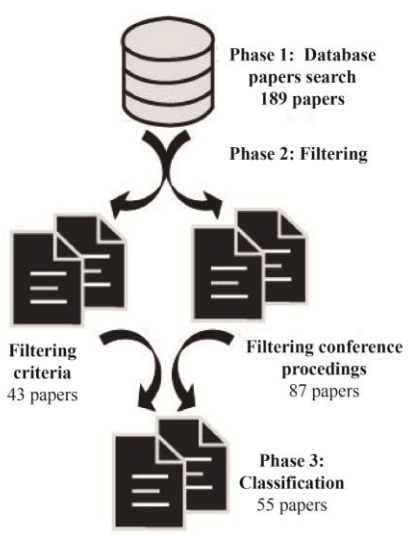


Fig 1 Study selection process

Table 3 Study classification

Stage/ Phases	Description	Papers
Systematic study of related articles	This category emphasis related articles that contribute to the understanding of methodologies and web engineering.	23
Comparison of methodologies	Studies related to the stages, tools, and characteristics of web methodologies.	10
Research methodology and related work	Articles used in the background of the investigation.	22

3.3.4 Data evaluation and extraction.

The activities estimated to carry out in this stage are:

- An author made a data extraction form, which covers the fields required and stipulated in the data collection section.
- The form is subject to evaluation whereby pilot tests with random selection of primary studies.
- Manually, an author extracted the results from each study, due to the small number of studies obtained.

3.3.4.1 Data collection.

For each assigned category, we collected specific data from each article of the SLR. For studies categorized as a **systematic study of referenced articles**, the extracted data were:

- The complete source and reference.

- The object of study.
- The author(s).
- The study approach.

For articles used in the results of the **comparative methodologies**, the extracted data were:

- Some definitions of development methodologies.
- The processes of each methodology.
- Tools that methodology use in each phase of the life cycle.
- Relevant characteristics for developer companies.

3.3.4.2 Data analysis.

The aims of the tabulated data obtained within the SLR were:

- Display the most flexibility methodology in its development stages (RQ2.1).
- The modeling tools that methodology use in each stage (RQ2.2).
- The dynamic features that tolerate each methodology evaluated in this study (RQ2.3).

Table 4 presents the comparison applied to the methodologies to understand the research question RQ2.1, taking as reference the researches of Byung-Kwon *et. all* [19] y Manhas [20] about the development processes of web-based applications and the tasks carried out in each of the phases.

Table 4 Phases and tasks in development process

Phase	Activities
Planning	•User model (grouping and classification)
	•Implementation of business plan.
	•Malleable elicitation and analysis of requirements.
Conceptual model	•Design of UML diagrams
	•Design of object views
Navigational model	•Navigational Requirement
	•Navigational diagrams.
Design	•Design of user interface diagrams
	•Design of prototypes.
	•Use of support tools.
Implementation	•Programming.
	•Detailed documentation.
	•Testing/ proof in each stage.

Meanwhile, for the evaluation of the UML modeling tools used in the life cycle (RQ2.2), the following stages are contemplated:

- Data modeling.
- Navigation model design.
- Presentation design

On the other hand, the comparison of dynamic characteristics of methodologies relays on the requirements engineering patterns presented in the Schön *et. all* research [21], which refers to agile requirements within the development process detailed in Table 5**.**

Table 5 Requirement engineering patterns

Problems	Patterns	Pointers
Discovery	• Eliciting and analyzing requirements.	Specification of elicitation and analyzing technique(s).
	• Inclusion of stakeholders	Throughout the process – In selected parts – Only in revisions.
Refinement	• Meetings with stakeholders.	Constant – Occasionally- Rarely
	• Addition of new ideas.	At the beginning of the project – In any stage – At the end of a stage.
	• Acceptance of continuous changes.	Easily accessible for changes – Slightly accessible – Not allowed changes.
Prioritization	• Measuring the value of requirements.	High hierarchy – Low hierarchy
	• Prioritization of functions.	High – Medium – Low
Review	• Review meetings with end users.	Constantly – Occasionally - Slightly
	• Checking functionalities implemented.	For development team – For the customer – For all the stakeholders.
Documentation	• Capturing discussion and changes.	Accurate – Roughly – On minor scale
	• Specification of functionalities.	Highly detailed – Lightly detailed - Little detailed

3.4 Field research.

The growing emergence of development methodologies for web applications has encouraged software developers to opt for more than just one, and in many cases, developers prefer hybrid methods. On the contrary, developer companies to select the accurate development method consider project qualities and features.

During the research carried out, we used the survey to contrast the theory obtained from SLR and the criteria issued by developer companies.

3.4.1 Participants

The target population for the survey is Ecuadorian software developers located in the AESOFT (Ecuadorian Software Association) directory [22].

The list obtained through the AESOFT organization brings together companies that produce, distribute, and develop software and provide computer services. We selected the companies destined for the resolution of the survey whereby their geographical location, taking into account cities such as Quito, Guayaquil, Latacunga, Ambato, Cuenca, and mainly the province of El Oro. Because of the high reception that these cities have in the development of software.

Straightaway, we filtered the companies according to the service provided, considering those engaged in the development and sale of software, and eliminating those related to telecommunications or the provision of computer services.

However, of the total number of companies designated (85 companies) to carry out the survey, only 34 developer companies replied.

3.4.2 Survey design.

To satisfy the main objective of the study, which is to identify if Ecuadorian development companies use methodologies during their process, a survey was carried out. The established questions allow knowing the opinions that the developers have concerning the development method that they apply.

Some questions (Q) set out in Table 6 intend to investigate the characteristics that benefit companies during the project life cycle in addition to discussing the experience gained by the developers.

Table 6 Field research questions

No	Question	Description
Q1	What kind of methodologies do you think are most appropriate for the development of Web applications today?	It seeks to know the inclination of the companies by the object-oriented methodologies or hybrids.
Q2	Which navigation design tool or data modeling technique do you think is most effective in demonstrating the processes to be performed within the Web application?	It looks for the comparison of the technique considered by the developers as effective, with the techniques used by the methodologies.
Q3	What stage do you think should be developed meticulously during the Web application development process?	To solve the problem of the methodology with the most flexible stage, contrasted with the literature.
Q4	What Web application development methodology do you use?	To identify the most practical methodology in Ecuador.
Q5	Do you agree that the Web development methodology you use gives you more security and ease in the development of a Web application?	To know the satisfaction that the companies have when using the methodology.
Q6	What approach do you consider to be paramount when using a hypermedia development methodology for a Web application?	To determine whether methodologies in general manage to meet the approaches that developers contemplate.

4 WEB APPLICATION DEVELOPMENT METHODOLOGIES

4.1 Object-Oriented Hypermedia (OO-H Method).

According to Muller *et. all* [23], the OO-H methodology is an object-oriented development methodology that focuses on a unified software structure.

In other words, behavior, structure, and presentation must remain combined to develop quality software.

OO-H also provides developers the ability to migrate web applications, due to it is an extension of UML and takes concepts from the Object-Oriented Method. The life cycle of this methodology presented in Fig 2, use case tools to simplify the design and implementation of the application [24].

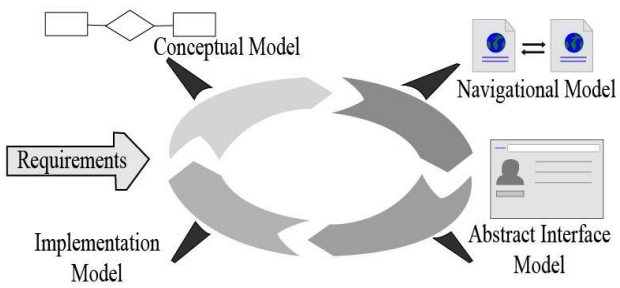


Fig 2 Model in OO-H Methodology.

The conceptual model uses contemporary views (object view and dynamics) to capture system behavior, while the navigation diagram defines the necessary navigation within the system structure. Templates are used within the design of the user interfaces to facilitate the implementation of the system modules.

4.2 Relationship Management Methodology (RMM).

RMM is flexible and allows maintenance and further evolvement of the application, which is an outstanding factor that applications must-have. The methodology aims to simplify the process of specification, analysis, and design of the systems to make it easier for developers.

According to Meso, Madey, Troutt & Liegle [25], this methodology takes an ecological approach, in which greater emphasis is placed on network-actor relationships so that the development process is exhaustive [26].

- Design of the Entity-Relationship (ER) model.
- Slice or slice design.
- Design of the navigation model.
- Design of the conversion protocol.
- Design of the user interface (UI)
- Behavior design.
- Construction and Testing.

4.3 Scenario-Based Object-Oriented Hypermedia Design Methodology (SOHDM).

Escalona & Koch define SOHDM as "the first approach that emphasizes the importance of a process that allows analysts to capture and define application requirements" [27].

The methodology employs scenarios within the requirements collection process, for which it uses procedural logic.

The use of scenarios facilitates the capture of dynamic requirements [28] and provides an advantage in applications with a large amount of information.

The process of developing this methodology is iterative and consists of five phases.

- Customer's analysis.
- Value analysis.
- Web design.
- Implementation design.
- Construction.

4.4 Web Modeling Language (WebML).

According to Bolchini and Paolini [29], it is created to develop complex websites more optimally and efficiently. For better presentation and data structure, WebML provides several hypertext views that focus on a specific need [30],[31].

This methodology presents two fundamental modeling dimensions, the data model (ER diagram), and the hypertext model describing the interconnections [32]. On the other hand, navigation contemplates two resources, the pages (navigation entities) and the links (connection of pages) [33].

The process of developing this methodology is incremental and iterative [34], i.e., the stages (Fig 3) must be refined to achieve an efficient site that meets the objectives and requirements requested.

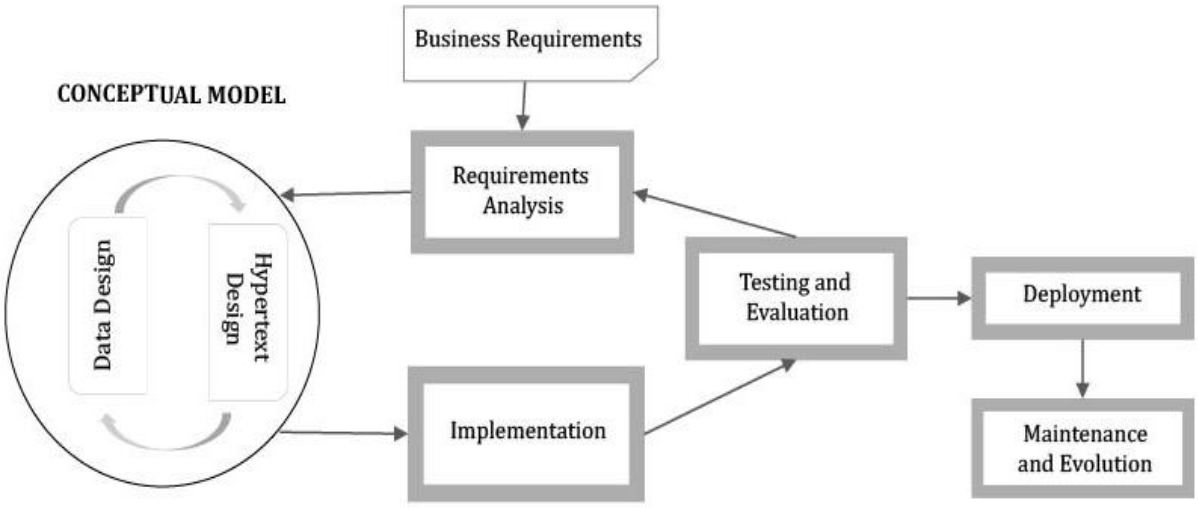


Fig 3 Development Phases of WebML methodology..

4.5 Object-Oriented Hypermedia Design Model (OOHDM).

The hypermedia object-oriented design model is considered to be one of the most popular web application design approaches due to its ease of abstraction in implementation [35]. OOHDM provides a successful method for developing hypermedia applications.

Besides, the employment of this methodology relies on specialized hypermedia design models, such as conceptual design, navigational design, and interface design [36].

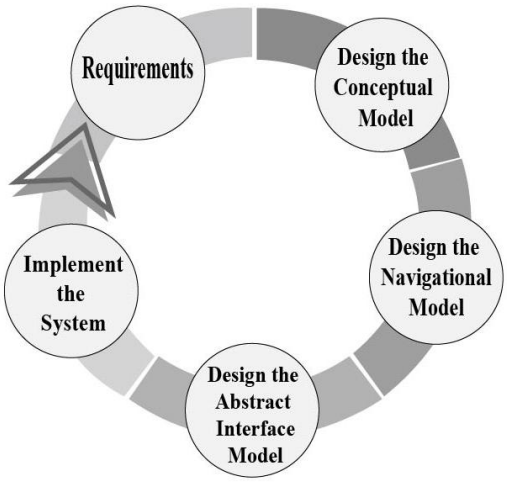


Fig 4 Development Phases of OOHDM methodology.

The development process (Fig 4) is similar to the hypermedia model and applies a heterogeneity of object-focused techniques, which are related to the design of user interfaces [37].

On the other hand, navigation employs the classes defined in the conceptual model, generating specific models that benefit the design process of the applications [38], [39].

4.6 Uml-Based Web Engineering (UWE).

The UWE methodology is "an engineering approach based on the model that focuses on helping the web engineer in the different phases of the development life cycle" [40].

UWE provides greater accessibility and manageability of requirements due to its inclusion in the early stages of the development process. This development approach "proposes expanded use cases, scenarios, and glossaries to specify requirements"[41], so there are a reliable collection and analysis of them.

UWE has a separate approach to concerns during its development processes, such as content, navigation, processes, or others. It takes into consideration three essential dimensions (Fig 5) for the design [42], including the business logic.

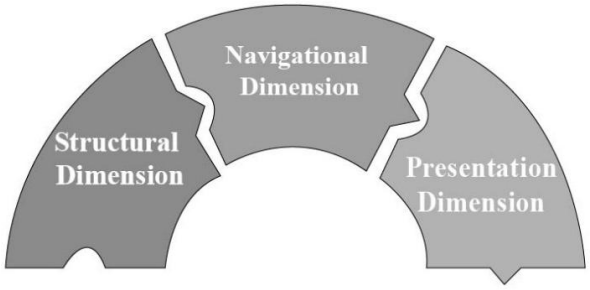


Fig 5 Dimensions in UWE methodology

4.7 Hera.

It is a model-driven methodology used to capture as many design aspects as possible, focusing on facilitating design execution for developers [43].

Hera allows the collaboration of external parties within the execution of some activities [44], based on the separation of concerns, and implementing meta-data.

According to Torre [45], the ontologies within this methodology are used to represent the concepts of domain,

i.e., the conceptual model, and the navigation structure. Because it "has its origins in the RMM design methodology"[46] and was developed specifically for data-intensive (large volume of data) interactive web applications.

Hera is composed of two phases; the first is data collection, which seeks to integrate different information so that it is available for quick consultation, while the second phase generates the presentation of data through domain and navigation models.

Table 7 Related Researches

N°	*Author*	*Title*	*Approach*
DOC1	H. Tai, K. Mitsui, T. Nerome, M. Abe, K. Ono, M. Hori.	Model-driven development of large-scale Web applications.[47]	The approach inn this paper describes a new meta-model and some peculiarities in modern web application development, including pages transition, structural page content and other techniques.
DOC2	S. Paydar, M. Kahani.	A semantic web enabled approach to reuse functional requirements models in web engineering.[48]	The author presents a necessary perspective in the paper, which is the use of UML diagrams to describe functional requirements in web applications.
DOC3	P. Valderas, V. Pelechano.	Introducing requirements traceability support in model-driven development of web applications.[49]	The main use for this paper in this study is the presentation of several software artifacts development methodologies, to trace navigational requirements and to analyze them with mechanism.
DOC4	S. Jeary, K. Phalp, J. Vincent.	An evaluation of the utility of web development methods.[50]	Among the results of this research there are a comparative, where different development methodologies are classified because of their features.
DOC5	P. Atzeni, P. Merialdo, G. Mecca.	Data-Intensive Web Sites: Design and Maintenance[51].	An important approach presented in this study is found in related work section, where it is presented different design process in several methodologies.
DOC6	H. Schmid, G. Rossi.	Modeling and designing processes in e-commerce applications.[52]	This article describes proposed extensions to OOHDM and explores their use at an online retail store.
DOC7	I. Aedo, S. Montero.	A methodological approach for hypermedia security modeling.[53]	The aim of this paper is show how to integrate security modeling and users into the development process.
DOC8	G. Vassiliki, E. Viennasa.	Design reuse in the conceptual schema of CMSs: A pattern-based evaluation approach.[54]	The author presents a brief overview about WebML methodology, including fundamental concepts and stages used inn methodologies.
DOC9	Maria J. Escalona, N. Koch	Requirements Engineering for Web Applications: A Comparative Study.[55]	The study presents a survey and comparative study of some approaches, including UWE, WebML, SOHDM, OOHDM, among others.

5 RESULTS

5.1 Systematic Literature Review of Referenced Articles

Some research, which meets the inclusion criteria, was not used within the conceptual rationale, but to provide additional focus and information to the reader. Table 7 presents the studies that give new knowledge about development methodologies.

5.2 Comparison between life cycle processes in development methodologies.

Each one of the selected methodologies presents different processes within the life cycle due to employment characteristics and the need to develop quality software whereby a simple process. Also, the fact that there exists a variety of stages in web methodologies presents a complexity at the moment of comparing them.

Under those circumstances, we defined some prevalent and essential stages that any agile web development methodology must-have.

To compare the methodologies, we consider some activities presented in the stages of the life cycle; thus, the analysis made in Table 8 established the most suitable method, not only into its stages but also into activities for dynamics environments.

Through comparison, it is possible to identify that the main activities to consider a methodology as suitable are to include stakeholders during the development stages, to allow changes in any stage, and to allow adding or modifying the requirements without this action negatively affecting the project.

Table 8 Activities within the life cycle of development methodologies

	Activities	OOH	RMM	WebML	SOHDM	OOHDM	UWE	Hera
Planning	User model (grouping and classification)	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*Yes*
	Implementation of business plan.	*No*	*No*	*No*	*No*	*No*	*No*	*No*
	Malleable elicitation and analysis of requirements.	*No*	*No*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Conceptual model	Design of UML diagrams	*Yes*	*No*	*Yes*	*No*	*Yes*	*Yes*	*Yes*
	Design of object views	*No*	*No*	*No*	*Yes*	*No*	*No*	*No*
Navigational model	Navigational Requirement	*No*	*No*	*No*	*Yes*	*Yes*	*No*	*No*
	Navigational diagrams.	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Design	Design of user interface diagrams	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
	Design of prototypes.	*No*	*No*	*Yes*	*Yes*	*Yes*	*No*	*No*
	Use of support tools.	*No*	*No*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Implementation	Programming.	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
	Detailed documentation.	*No*	*No*	*Yes*	*No*	*No*	*Yes*	*No*
	Testing/ proof in each stage.	*No*	*No*	*Yes*	*Yes*	*Yes*	*No*	*No*

When a company incorporates stakeholders from an early stage, they must consider some specific indicators, like the presentation of the user model correctly with end-users, customers, and development teams identified and classified appropriately.

Based on the comparison, we can state that WebML, OOHDM, and UWE are suitable methodologies for dynamics development environments, due to its organized structure about stakeholders' functionalities, and the malleability characteristics presented during the project. Also,

As a result of the analysis, UWE uses tools that encourage the development of web projects during all stages, also including UML models to diagram the design of the conceptual and navigational model generates easily understandable diagrams for the stakeholders carrying out an implementation stage suitable for the development team.

5.3 Modeling tools during project development.

The research carried out by other authors and included in this study, serves as a fundamental approach for the comparison between the tools used by the development methodologies detailed in Table 9.

views, and presentations in each phase. Unlike other methodologies, UWE does not employ modeling tools or combine artifacts to design, which allows all stakeholders and new members to understand and manage the models.

Table 9 Comparison between Web application development methodologies

	Data Modeling	***Navigational Diagram Design***	***Presentation Design***
OOH	OO Model	OO Model	ADP
RMM	ER Model	ER Model	--
WebML	ER Model	Views (Pages and Links)	--
SOHDM	Scenarios	OO Model and Scenarios	OO Views
OOHDM	OO Model	OO Model	ADV
UWE	UML Artefact	UML	UML
Hera	RDFs	Application Model	Static and dynamic presentations.

Table 10 describes some acronyms used for the previous comparison of web application development methodologies.

Table 10 Acronyms

Acronyms	**Meaning.**
OO Model	Object Oriented Model
ER Model	Entity-Relationship Model
RDF	Basic language of the Semantic Web.
ADP	Abstract Presentation Diagram.
ADV	Abstract Data View.
UML	Unified Modeling Language.

5.4 Problems patterns during the development process of a web project.

Flexibility within a web project is fundamental for efficient development, and one of the ways to obtain it is through activities that promote the inclusion and malleability of the stages. Web-oriented projects often have specific features, including the need to add new pages to the application or to satisfy different end-users. The inclusion of these characteristics implies the appearance of problems, such as adaptability to new requirements, prioritization of functionalities, and adequate documentation.

Although each of the methodologies has different techniques and tools, with which they manage to overcome the difficulties that arise during the process, they are not always the most appropriate. The problems faced by companies during the performing of a project raise on the elicitation phase, due to each company implements the most suitable tool for the discovery of requirements, which can be own or standardized.

Developers try to follow a simple and easy process for the maintenance and update of the application. Therefore, it is necessary that a suitable methodology for the development process is flexible in the face of changes and generates speed in the delivery of the product.

Table 11 Comparison between Web application development problems

	Patterns	OOH	RMM	WebML	SOHDM	OOHDM	UWE	Hera
Discovery	Eliciting and analyzing requirements.	*Interviews, uses case modeling, UML diagrams*	*Relationship management data model*	*Interviews, Story-boarding*	*DFD, scenario*	*Uses case modeling*	*Interviews, questionnaires and checklist*	*Interviews*
	Inclusion of stakeholders	*In selected parts*	*In selected parts*	*Throughout the process*	*Throughout the process*	*Throughout the process*	*Throughout the process*	*In selected parts*
Refinement	Meetings with customer (end user).	*Occasionally*	*Rarely*	*Occasionally*	*Constant*	*Occasionally*	*Constant*	*Rarely*
	Addition of new ideas.	*At the end of a stage*	*At the beginning of the project*	*At the end of a stage*	*In any stage*	*In any stage*	*In any stage*	*At the end of a stage*
	Acceptance of continuous changes.	*Slightly accessible*	*Not allowed changes.*	*Easily accessible for changes*	*Easily accessible for changes*	*Easily accessible for changes*	*Easily accessible for changes*	*Not allowed changes.*
Prioritization	Measuring the value of requirements.	*Low hierarchy*	*Low hierarchy*	*High hierarchy*	*High hierarchy*	*High hierarchy*	*High hierarchy*	*Low hierarchy*
	Prioritization of functions.	*Low*	*Low*	*Medium*	*High*	*Medium*	*High*	*Low*
Review	Review meetings with end user.	*Slightly*	*Slightly*	*Occasionally*	*Occasionally*	*Occasionally*	*Constantly*	*Occasionally*
	Checking functionalities implemented.	*For development team*	*For all the stakeholders*	*For all the stakeholders*	*For development team*	*For all the stakeholders*	*For all the stakeholders*	*For all the stakeholders*
Documentation	Capturing discussion and changes.	*On minor scale*	*On minor scale*	*Roughly*	*On minor scale*	*Roughly*	*Accurate*	*On minor scale*
	Specification of functionalities.	*Little detailed*	*Highly detailed*	*Highly detailed*	*Little detailed*	*Highly detailed*	*Highly detailed*	*Little detailed*

Considering the development conditions, we compared the development methodologies in Table 11 according to the activities that present significant problems during the development process. UWE contemplates strategies and tools that allow the developer to solve common problems within the life cycle, emphasizing the ease of change, the use of standard techniques that are easy to understand, and the constant review of progress.

Although methodologies such as OOHDM, WebML, and SOHDM present a high understanding in stages such as refinement, prioritization, and revision, they have a limited outcome in the documentation phase since they do not require changes and functionalities.

5.5 Field Research.

The results of the field research favor the understanding of the methodology most employed by software development companies within Ecuador. Also, characteristics considered by the developers at the time of selecting the method, such as the approach proposed, and the most significant stage, are explored.

Below, we analyze the results obtained within each of the questions posed in the survey.

Q1: *What kind of methodologies do you think are most appropriate for the development of Web applications today?*

Table 12 Web Application Development Methodologies

Methodologies for the development of web applications.	%
For hypermedia design.	12%
Object-oriented	29%
Hybrid.	59%

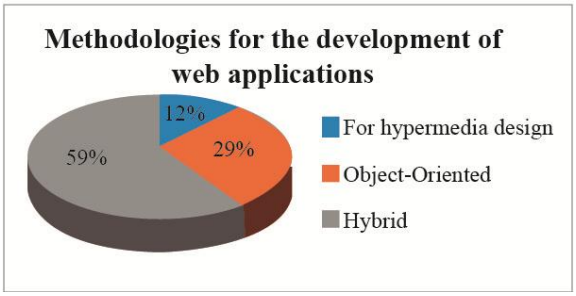


Fig 6 Web Application Development Methodologies

Fig 6 shows a preference of 59% in the use of hybrid methodologies due to the more complete and agile processes they contemplate additionally to adapt the life cycle to the needs of the company. On the other hand, 29% of companies choose to use object-oriented methodologies.

Q2: *Which navigation design tool or data modeling technique do you think is most effective in demonstrating the processes to be performed within the Web application?*

Table 13 Data Modeling Technique

Data Modeling Technique	%
Entity-Relationship (E-R)	0%
Object-Oriented	73%
Scenarios or Views.	27%

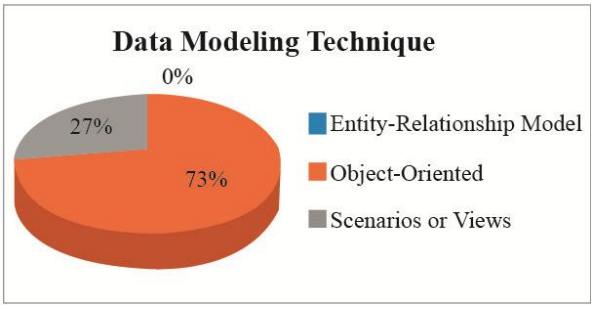


Fig 7 Data Modeling Technique

Fig 7 manifests that more than half of the companies surveyed consider the Object-Oriented data modeling technique to be the most effective for demonstrating processes within a web application. Meanwhile, a small range is inclined to use scenarios or views for navigational design.

Q3: *What stage do you think should be developed meticulously during the Web application development process?*

Table 14 Development Stage In Life Cycle

Development stages	%
(P1) Conceptual Model Design	53%
(P2) Navigational Model Design	9%
(P3) Presentation Design	29%
(P4) System Implementation	9%

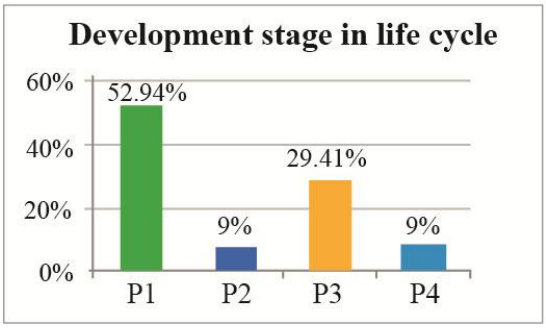


Fig 8 Development Stage In Life Cycle

According to Fig 8, most of the companies agree that the conceptual model design stage is the phase in which should have the most concern. This stage contemplates the processes of elicitation, analysis of requirements, and design of diagrams, so it must be done right without significant changes.

On the other hand, the second concern within the development process is the presentation design. This stage includes the design of user interfaces and prototypes of the application. Some of the companies argue that an application must have high-grade functionality and be pleasant for the user, therefore the high importance of both stages.

Q4: *What Web application development methodology do you use?*

Table 15 Web Development Methodologies

Development methodologies	#
OOH	2
RMM	0
WEBML	4
SOHDM	3
OOHDM	7
UWE	8
HERA	0
Other	10

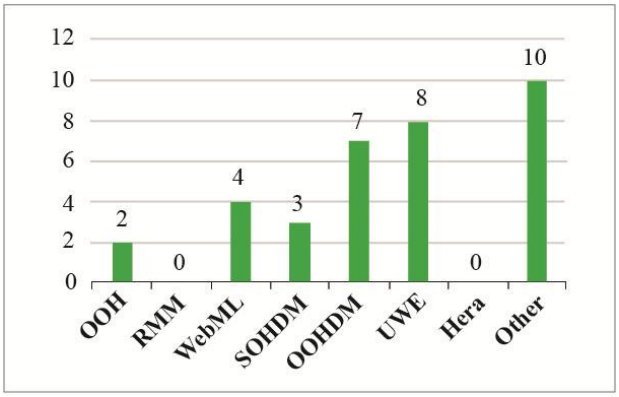


Fig 9 Web Development Methodologies

Fig 9 indicates that there is a high demand for the use of other development methods, most of which are hybrids. On the other hand, some companies use models, among which are cascade, spiral, or methodologies SCRUM and XP.

Considering the companies that use some of the evaluated methodologies, it is possible to contemplate that developers prefer using UWE during web project due to the use of easy-to-understand diagrams, not very demanding activities, and the satisfactory results achieved.

Q5: *Do you agree that the Web development methodology you use gives you more security and ease in the development of a Web application?*

Table 16 Security in Life Cycle

Options	%
Totally agree	46%
Agree	45%
Undecided	9%
In disagreement	0%
Totally in disagreement	0%

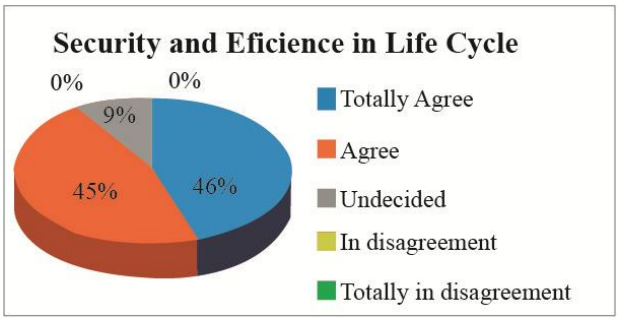


Fig 10 Security in Life cycle

Through Fig 10, it is possible to affirm that most of the companies accept the fact that the web methodology they have used provides security and ease during development. On this basis, we argued that employing a development methodology during the process allows the management of quality projects.

Q6*: What approach do you consider to be paramount when using a hypermedia development methodology for a Web application?*

Table 17 Hypermedia Development Methodology Approach

Hypermedia development methodology approach	%
Task-driven approach.	73%
Content-driven approach	27%

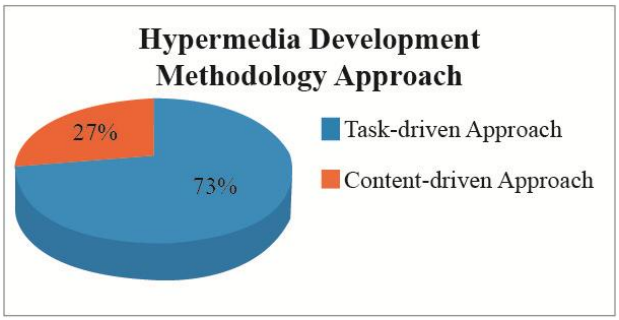


Fig 11 Hypermedia Development Methodology Approach

In Fig 11 shows that 73% of companies consider that task-driven has better benefits during development, while 27% use the content-driven approach.

6 DISCUSSION OF THE RESULTS

Web application development methodologies differ on a large scale from those used in desktop software. One of the principal differences relais on the stages and its structure, in which navigational design appears as the primary requirement, and other pashes, such as conceptual design, presentation, and implementation, remain unchanged. In spite of having similar bases, each of the methodologies presents specific approaches with appropriate tools and activities.

The use of literature within research attempts to know the characteristics and benefits provided by each of the methodologies to identify the most suitable for the development of web applications. Several authors, such as Gitzel, Korthaus & Schader [35], and Avgerious & Retalis [36], consider in their research that the OOHDM methodology presents techniques to optimize the process in addition to being mentioned on a large scale in the literature. Nevertheless, evaluating the features obtained in primary studies, it is determined that UWE presents activities that facilitate project management. Some of the

activities include the use of design tools to quick understanding, the inclusion of the client to avoid hasty modifications, and constant progress reviews.

The analyzed literature provides the necessary bases to be able to study the behavior of the methodologies in the field research. As a result of the survey, it was possible to verify that OOHDM is mention at a high-level by literature; but within the labor market, it is almost not employed.

Some reasons are that companies opt for using hybrid methodologies or prefer a development method based on experience. Although many managers know the development methodologies, they prefer to guide the process based on the knowledge acquired in previous projects.

Regardless of the method employed, managers must consider the basic life cycle for web applications, requiring further attention at the conceptual design and presentation stages due to the complexity and prioritization that the activities present during these stages in the development process.

Commonly, the problems prevented with the use of the methodologies, are equal to the considerations of managers to select a development method; the activities identified are (1) the correct elicitation of requirements, (2) the inclusion of stakeholders, (3) the adequate analysis of the functionalities to represent in the diagrams, (4) the use of UML devices for better understanding, (5) prototyping, and (6) creation of a pleasant user interface, which complies with the usability rules.

Although the research (SLR and field) leads to different results, both converge in the assertion that the UWE methodology presents characteristics that benefit the development team, and the project because the use of less complicated tools (UML) and the proper management of activities during all phases required to develop a web application. Also, UWE allows constant communication with the customer during reviews and design stages that facilitate the development of the web application, without the need for hasty changes, which can affect the planning and delivery of the product.

7 CONCLUSIONS AND FUTURE WORKS.

The main contribution of this article is field research within the Ecuadorian development market, identifying the most widely used methodology, as well as its relevance within the project. Thanks to the studies, it was found that most national companies use different methods than those studied (OOH, RMM, WebML, SOHDM, OOHD, UWE, or Hera), employing instead hybrid methodologies or processes guided by experience.

Despite knowing the methodologies, some managers opt for traditional or unsystematic development processes. This decision is due to two reasons, the first is the size of the project, and the second is the short delivery time. If it is a small project, managers and developers govern the implementation of functionalities and documenting what is needed to achieve updates of future versions; on the contrary, it is necessary a better planning to reach the established deadline.

However, not following an adequate development process negatively affects the project, a clear example is the documentation. Many developers prefer superficial documentation but, by not registering the appropriate changes, functionalities, or diagrams, the project will present delays in its delivery due to lack of understanding of the work team.

As a researcher, the fact that most companies do not use one of the assessed methodologies means that companies consider other needs, different from the problems proposed within the research, apart from having more confidence in empirical processes than in guided and time-consuming guidelines.

Finally, based on the analysis of the field research and the SLR, we conclude that not all Ecuadorian developers make use of some of the seven methodologies assessed; the vast majority use hybrid ones or methods based on experience. However, we propose UWE as the most suitable for web development because it provides security, ease, and extensive benefits to the project found in the literature.

Future work will focus on two complementary perspectives. The first one will be the justification of the importance of methodologies within the development process based on the developer's experiences during projects. The second one will be the identification of strategies for a correct selection of development methodology. Both research guidelines will be carried out through empirical or field research, as appropriate.

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